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Alternative manufacturing developments
from the semi-periphery: the case of
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Gustavo Abel Guzman
University of Wollongong

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**ALTERNATIVE MANUFACTURING DEVELOPMENTS
FROM THE SEMI-PERIPHERY : THE CASE OF HUMAN-
CENTRED MANUFACTURING APPROACH IN BRAZIL**

**A thesis submitted in partial fulfilment of the
requirements for the award of the degree**

DOCTOR OF PHILOSOPHY

from

THE UNIVERSITY OF WOLLONGONG

by

Gustavo Abel Carrillo Guzman, BEng, MA

Science and Technology Studies

June, 1998

I declare that work presented in this dissertation is original, except where otherwise acknowledged.

June 1998

Gustavo A.C. Guzman

ABSTRACT

The key research question of this study is to determine if Brazilian firms are applying the human-centred manufacturing approaches and if so, to explore how and to what extent this is happening. From this, two related research topics emerge: (i) how macro contextual conditions support or constrain the implementation of the HC model; and (ii) which are the main technical and organisational features of a 'tropicalized' (adapted) HC model in Brazilian firms. In order to address these questions, case studies were carried out in 10 Brazilian firms. The aim of the empirical study was to determine the form and level of human-centredness in these firms and to explore the factors affecting this. An examination was then made of the patterns of human-centred development and its links with product, process and environmental factors, identified in the literature as key influences on HC systems developments. Two theoretical approaches were used to inform the empirical component of this study in order to explain the application of New Production Systems and, specifically the Human-centred approach in the semi-periphery. Firstly, the examination at the level of the firm, integrates constructivist views of people, technology and organisation with the concept of manufacturing engineering systems as well as the organisation configuration approach. This helps to understand "how" the human-centred approach was applied in Brazil. Secondly, a political economy examination of the macro contextual factors assisted to understand "why" related questions. Key findings of this study refer to the wide range of adaptation to local conditions of new production systems. This is explained by contextual institutional factors, such as industrial relations and regional labour markets. In contrast to established human-centred theory, the degree of human-centredness in the organisational arena was not strongly linked to either (i) human-centred designed technology; (ii) to new product market variety and change; or (iii) characteristics of the firm.

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Abbreviations

AMT	Advanced manufacturing technology
APS	Anthropocentric production systems
BRITE	Basic research in industrial technologies for Europe
CAD	Computed-aided design
CAM	Computer-aided manufacturing
CIM	Computer integrated manufacturing
CLP	Capitalistic labour process
CNC	Computer numerical control
CPU	Central process unit
DQP	Diversified quality production
ESPRIT	European strategic program for research and development in information technology
EURAM	European research for advanced materials
HC	Human-centred
HCMS	Human-centred manufacturing systems
IBGE	Instituto Brasileiro de geografia e estatística
FAST	Forecasting and assessment in Science and Technology
FDI	Foreign direct investment
FMS	Flexible manufacturing system
GDP	Gross domestic product
GNP	Gross national product
GT	Group technology
ITC	Indigenous technological capability
ISI	Import substitution industrialisation
JIT	Just-in-time
MES	Manufacturing engineering systems
MNC	Multinational companies
NC	Numerical control
NCMT	Numerical control machine tool
NIC	Newly industrialised country
NPC	New production concepts
NSI	National systems of innovation
OEM	Original equipment manufacturer
PCF	Product customisation feasibility
PPC	Production planning and control
R & D	Research and development
SBIC	Study of the Brazilian industrial competitiveness
SENAI	Servico nacional de aprendizado industrial
SOE	State-owned enterprise
SPC	Statistical process control
STS	Science, Technology and Society
S & T	Science and technology
TNC	Transnational companies
TQM	Total quality management
TU	Trade union
UMIST	University of Manchester institute of science and technology
WIP	Work in-process

CHAPTER 1

INTRODUCTION

There was a time when groups of highly qualified and self-managed workers performed their activities in such a way to obtain customised products with high quality, in short time and could rapidly react to last minute modifications in product features, volume of production and size of batches. Capital and labour relations were no longer contradictory and because workers and employers agreed on the task of increasing customer satisfaction to secure both profits and working conditions Trade Unions were no longer necessary. Experts suggested that 'New Organisational Forms' made feasible sustainable industrial growth.

This dissertation is not about an ideal world where the application of particular form of organising industrial work would be free of problems. Conversely real world application of new organisational forms seems to have massive implications for society since a wide range of economic and social outcomes for different social actors is possible.

So far, it has been clearly established that important changes are occurring in the world economy - and this is directly reflected in the way firms organise operations and compete. The nature of these changes and their micro and macro implications however, are still little understood (Durand, 1993). Firstly, observers do not agree whether or not the 'Golden Age' of fordism is coming to an end. To what extent are fordist type factories alive ? To what extent are traditional fordism factories changing work practices and product technology strategies ? What is the pace of change ? Moreover, how does this occur both in industrialised and under-industrialised nations ?

Secondly, new organisational forms are, without doubt, being introduced in order to cope with new forms of competition. Nevertheless the goals and results of the implementation of those new organisational forms vary in a significant extent. Different nations with different

Thirdly, because the adoption of new organisational forms is still in its early stages, little is known about how this process is developing at company level. Which are the preferred patterns of adoption ? Which are the commonly accepted features of new organisational forms that firms are adopting ? Does a 'universal' model of new organisational forms exist ? Or are there alternative models to choose ? How are different 'models' of new organisational forms being adapted to specific national conditions ? Which model is 'superior' ? Are these new organisational forms equally applicable to different industrial sectors ? To what extent are new organisational forms adopted in different national settings ? What are the implications of adopting or not adopting new organisational forms for firms, workers and national economies ? To what extent are new organisational forms - such as humane forms of jobs and working conditions - compatible with the principles of capitalistic production ? Does new organisational forms deserve to be qualified as 'paradigmatic' ?

Regarding semi-peripheral nations¹, the same set of questions remains open since very little is known about contextual and institutional conditions. Despite the fact a body of literature does exist regarding the use and application of non-tayloristic work and organisational forms since the early 1980s (cf, Martin, 1983; Brodner, 1986; Kopacek and Gencer, 1990; Karwowski and Salvendy, 1994; Kidd and Karwowski, 1994; Brandt and Martin, 1995; Koubeck and Karwowski, 1996), this research has focused on developed nations. Pertinent questions then are related to the search of the prevalent factors that shape the application and outcomes of new organisational forms in semi-peripheral nations.

This research focuses on the case of Brazil since it represents a typical semi-peripheral nation. Findings of this research then can be used as background arguments in the study of new organisational forms in other semi-peripheral nations, specially Latin American economies. Research finding however, can not be generalised, not only because of the methods used (case study based) but also because of the overwhelming importance of macro-institutional factors, which are specific to each nation.

¹ The concept of semi-periphery refers to the group of nations that fall into the in-between area of core and peripheral nations. In a world system of unequal exchange (ie, core nations produce and sell high-wage products and peripheral nations produce low-wage products), 'the productive activities of these semi-peripheral countries are more evenly divided. In part they act as a peripheral zone for some countries and in part they act as a core country for some peripheral areas. Both their internal politics and their social structures are distinctive, and it turns out their ability to take advantage of the flexibility offered by the downturns of economic activity is in general greater than that of either the core or the peripheral countries' (Wallerstein, 1979: 97).

Because of both the emerging globalisation process and the opening of its economy, Brazil has been modernising its industrial structure since the early 1990s². This involves, among other items, improving the existing manufacturing infra-structure, strategies and practices. While the Japanese Lean production approach is widely diffused in Brazil, it is embedded into the traditional taylorist and fordism practices of Brazilian industry. The study of the application and potential diffusion of the HC approach in Brazil therefore, is important since it represents an alternative way that might contribute to improving industrial competitiveness, re-directing its current industrial practices towards more humane work organisation forms, upgrading its product markets (from low value-added/cost/wage based to medium value-added/skills/wage based), and re-focusing its manufacturing structures (from high division of labour/centralisation to lower division of labour/centralisation). The understanding of the (technical, social and political) processes that occur during the application of HC principles in a semi-peripheral economy can contribute to answering some of the above questions.

Finally, it is important to observe how different perspectives arrive at conflicting conclusions regarding outcomes of implementing new organisational forms (Durand, 1993). While economists present new organisational forms as the necessary complement to liberal economic policies (eg, zero import barriers, total goods and capital mobility as well as minimum State intervention) to sustain economic growth, sociologists present a darker view: A raise in educated unemployment, erosion of power of workers associations and the continuing increase of social and economic inequalities, inside firms (eg, core and peripheral workers), among firms (eg, core and subcontracted firms) and between industrialised and under industrialised nations.

1.1 THE RESEARCH QUESTION AND JUSTIFICATION

This dissertation focuses on the third set of questions as little research and agreement exists regarding those points. More specifically, the central question developed in this dissertation is related to the application of a particular type of new organisational forms, the Human-centred Manufacturing (HCM) approach, in a semi-peripheral nation like Brazil. This would contribute to the further understanding of the application of different production models in different settings other than the one from which the original idea was derived³. Therefore, this

² The emerging globalisation process influences the application and diffusion of new organisational forms. Which are the inter-relationships between new trade agreements among blocks of nations, the role of industrialised and under-industrialised nations and emerging forms of competition ? How do individual national differences affect this process ?

³ Unravelling how HC work and organisational principles are applied in a semi-peripheral nation is an important research question as current studies on the application of HC principles focus on the engineering

study is both a theoretical and empirical contribution to knowledge about Human centredness and in doing so addresses three key questions :

- ◆ How are HC principles applied in semi-peripheral nations like Brazil ?
- ◆ How do institutional conditions affect the implementation of HC organisational principles?
- ◆ What are the key factors that shape the application of HC concepts ?

This research focuses on the adoption of HCM in Brazil for the following reasons:

Despite Brazil have been traditionally a taylorist-fordist nation, it currently posses a highly heterogeneous industrial structure. This means room exists to implement new production concepts, as Brazil is still looking for a 'model' to pursue further industrial development. While alternative production models are being used/tested in particular industrial sectors⁴, a consistent model does not seem to exist;

The diffusion of the HC approach in Brazil seems to be feasible since firms applying new production concepts are role models for less developed and following firms. This is because the empirical study was performed on a selected sample of high technology-high profile firms.

Brazil is an important emerging market and one of the ten largest economies (in GNP terms) of the world (The World Factbook, 1996). As such, Brazil's economic performance will affect industrialised nations performance too;

Alternative New Production Concepts (NPC) such as the Japanese Lean Model have already been studied but little information is known or diffused about European style NPCs in Brazil⁵;

Little research exists on the feasibility of applying NPCs in semi-peripheral nations; on the process of adoption and on the contextual factors that support or hinder its application. This research not only helps the process of adoption to be understood (ie, how different factors

industry of developed nations, leaving a research gap in other industry sectors in different national settings (cf, Brodner and Karwowski, 1992).

⁴ There exists some empirical evidence that suggests that alternative organisational forms are being applied in Brazil (cf, Meyer-Stemmer, 1991; Silva, 1991).

⁵ Although it has been recognised that industrial competitiveness acquisition can be achieved in different ways and that different outcomes are possible (Turner and Auer, 1992), literature has mainly focused, on one single strand of restructuring, namely, the Japanese or (transplanted) lean model. Convergence, adaptation and the effectiveness of Japanese style manufacturing practices in Western settings are the main themes of research (cf, Abo, 1994; Oliver and Wilkinson, 1992)

converge to produce a specific outcome), but also to inform policy makers on how to address potential negative outcomes;

The promotion and development of the HC approach can also contribute to overcoming the widely diffused taylorist and fordism industrial practices. As Brazilian industrialisation has failed to translate economic achievements into social development, the use of HC principles can be one important element in addressing the current uneven patterns of income distribution⁶ by promoting the development of tasks that need skilled workers.

It has been pointed out that the HC model is quite well suited to sophisticated (small batches) high quality/price markets. According to Sorge and Streeck (1988), the choice of specific product markets not only defines product scale, scope and batch size but also selects a general trajectory of work organisation and manpower skills needed to satisfy that specific market target. So, how will HC principles be applied in the case of a mass-producer nation like Brazil ? How do macro contextual factors influence firm level deployments ?

Two complementary approaches were used to understand the application of new production systems (and specially HC concepts). First, a political economy argument was used in the examination of macro contextual related developments in order to aid in the understanding of "why" related questions. Second, a configuration/processual approach was applied in the examination of firm level deployments in order to assist to the understanding of "how" related questions.

As an introduction to the HC model the next section briefly outlines key elements of the HC perspective. Before this, in what remains of this section, the concepts of New Production Concepts (NPC) and New Production Systems (NPS) are reviewed.

NPCs are defined as firm level new organisational arrangements applied in manufacturing related areas. It is possible to distinguish 3 basic types of NPCs: the Swedish (or socio-technical), the Japanese (or 'Lean') and the German type. Depending on the depth and breadth of the restructuring and independently of the model used, results can be from a real change of production model to the re-invention of current models (eg neo-taylorism). The idea of NPC

⁶ Brazil is seen as a paradoxical model of industrialisation. On the one hand, in 1965 for example, there were 2,500 people to each physician. In 1984 the figure decreased to 1,080. In 1965 only 2 % of the population had access to tertiary education while in 1986 only 36 % of the population had access to secondary education. These figures reflect the uneven patterns of income distribution. In 1972 the highest 20 % of the population shared 66,6 % whilst the lowest 20 % only 2 % (World Bank, 1989). On the other hand, Brazil not only created an indigenous technological capacity, but also future expectations are high. The 1994 World Competitiveness Report (FSP, 1995) for example, included Brazil in the select group of nations (in the Eleventh position) which will be among the most competitive by the year 2030.

nevertheless, explains firm level developments without looking at external factors. In order to address this shortcoming, the present research uses the concept of 'New production Systems'⁷.

The concept of New Production Systems (NPS) involves the examination of both micro (firm) and macro level issues that permeate the application of NPCs. According to Boyer (1993) NPS is a productive model defined as the coherent outcome of management principles, the firm's internal organisation and wage relationships. Because the crisis of fordism, new internal organisational forms and new wage relations started to emerge as a response to new forms of industrial competition. Nevertheless, as different social actors, with different interests and power position, shape these dimensions, this process is complex and contradictory⁸. At the micro level, full utilisation of people's skills and technologies to respond to new demand types, calls for re-arranging work organisation, decentralising decisions, re-integrating tasks and fully co-ordinating processes among units. Competence and loyalty become the core criteria to set up rewards policies. The feasibility of this production system depends on its capability to respond to structural fluctuations. At the macro level, production decentralisation needs efficient transport and inter-exchange of communications systems. Access and diffusion of technology and knowledge calls for national and/or regional co-ordination with Universities, research centres and economic incentives for R & D developers. Uncertain and varying demand calls for skilled and competent workers to cope with uncertainties related to products, machinery, materials and information within tight time constraints. To this end, the existence of a high quality general educational system and vocational training systems fine tuned with industry needs is necessary. Again, State and private sectors need to co-ordinate efficient ways to finance, set up and develop education and training institutions capable of delivering prepared personnel. To support those principles the rewards contract needs to

⁷ Herein the word 'system' is used to describe approaches of organising and managing production practices as serious problems exist with the word 'model'. Usually production models are approached as static but in reality they are dynamic as they represent a particular set of conditions in specific terms of time and space. While each production model has specific micro level features and some similar ones, the bundle of all features seems to represent the core of the model as one feature reinforces another. Defined in those terms however, models are static representations as they fail to include the changing nature of 'key features' that each model can have. Nevertheless, the bundle of features is not static. Because both there exists a wide variety of forms of NPCs' application, and models are just theoretical conceptualisations of a particular trend, which follows specific logic, within particular time and space boundaries, the bundle of features that compound a particular 'model' is not static. Nevertheless, due to practical reasons, academics, consultants and industry practitioners raise the commonly accepted 'bundle of features' to the status of model. Then, it is necessary to remark that not only 'pure' models do not exist but also 'different' theoretical versions of models exist. This calls for the acknowledgement of the inadequacy of the concept of 'model' to describe a production system. However, the use of the concept of model was useful as it helped to capture key features and differences of varied models.

⁸ Crisis of fordism nevertheless, does not mean new forms of competition are occurring in all industrial sectors. Conversely, it seems to be occurring only in particular industries and more in some nations than in others. Moreover, fordist production systems still continue to be the common model in developing nations (Boyer, 1993).

reflect the new reality of work. In Japan for example, large enterprises offer life-long employment and in Sweden an employees/employers/state agreement to maintain full employment existed. The key point is that employees need a different wage relationship in order to accept new working demands.

Further light was thrown on the characterisation of New Production Systems (NPS) by Badham and Mathews (1989). Their contribution links (i) product innovation, defined as frequency and degree of change in product features; with (ii) process variability, defined as frequency and degree of change in production methods; and (iii) labour responsibility in manufacturing. This model is useful because it helps to differentiate production strategies such as Fordist, Neo-Fordist and Post-Fordist. Nevertheless, it is still too rough to clearly differentiate different models (made up of specific relations between these elements) within the Post-Fordist region⁹.

1.2 HUMAN-CENTREDNESS: A BRIEF CONCEPT

The HC approach is a research program that emphasises and supports the development and diffusion of both technological and organisational restructuring. It does so via the principles derived from Tavistock's socio-technical school, Scandinavian Democratisation of work traditions and work and management practices in Germany's skilled-based capital goods industries. It is a pro-active approach to creating alternative technology and production methods as well as their diffusion and application (Badham, 1990). The HC movement, following the incorporation of selected features of the above views, underwent changes in their organisation and found institutional support in Germany, the United Kingdom, and in the Scandinavian nations¹⁰. This was to develop a production model compatible with European values and culture and to challenge the 'Japanese threat'.

⁹ How can one differentiate for example, the Japanese lean model and Business Reengineering (Hammer, 1990), from the HC model ?

¹⁰ The HC starting group was derived by Engineering Academic Scientists. Early insights of E. Mumford, M. Cooley, H.H. Rosenbrock and P. Brodner constitute the foundation of the HC movement. This is important because unlike the cases mentioned above the engineering profession possesses a significant influence on the setting up, application and diffusion of production philosophies (the case of Japan for example is illustrative. The Japan Institution of Engineers - JUSE and the MITI's pro-active policies to support producers-overseas market interface were crucial in developing, adopting and diffusing their own production systems based on the Toyota experiences). Some of the institutions involved in researching different aspects of the HC model (Badham, 1991) are The European Commission Forecasting and Assessment of Science and Technology (FAST) program, the German Research and Technology Ministry through the Manufacturing Technology Program and Work and Technology Program, the Economic Community ESPRIT and BRITE-EURAM programs, the CEDEFOP vocational training Implications Program. Within these research programmes a wide range of professionals such as engineers and computer scientists converge to create CIM components; human factors practitioners to design and implement human-machine interfaces; management

The HC approach, while drawing heavily on the socio-technical theory, attempts to address the important shortcomings of this viewpoint¹¹ (Corbett, Rasmussen and Rauner, 1991). (i) By viewing technology as socially constructed and by promoting the re-design of technology, the HC approach overcomes the socio-technical weakness of adapting social organisation to technology; (ii) the HC approach acknowledges capital/labour conflict relations; (iii) by considering wider social factors to explain work and technology relations the HC approach overcomes a 'narrow' definition of the environment; (iv) the HC approach emphasises the role of the worker's tacit knowledge in the production process, an often overlooked factor in socio-technical theory; (v) recognises that the autonomy principle of socio-technical systems is not the only possible solution to human work redesign¹² (Klein, 1994); (vi) HC approach emphasises both shopfloor and firm level examination in contrast to the traditional socio-technical view that tended to concentrate upon groupwork at shopfloor level; and (vii) the HC movement emerged not only as a response to widely justified social issues of democratisation and labour reform, but also as a sustainable and profitable economic strategy. For proponents of HC theory it is clear that addressing industrial issues and problems solely in terms of 'social' values results in short-lived solutions.

Three arguments justify the emergence of the HC movement (Badham, 1991). The first of these is the human factor argument which observes that technical systems are not productive enough with human and organisational problems identified as the principal reasons for this¹³. Secondly, the socio-technical argument which emphasises the fact that high task uncertainty and complexity results from increasing product customisation rate and smaller batch size. This also calls for a new design of jobs that takes all those environmental conditions into

scientists and consultants to offer different insights into implementation; innovation policy analysts to prescribe how to diffuse the process; education and training personnel to research new forms of skills needed and to provide training and, finally, industrial sociologists to study outcomes and appropriate forms of skills and work organisation.

¹¹ For an outline of contributions and limitations of socio-technical systems theory see Chaptre 2.

¹² In some situations it may not be the first priority. Thus, participating design methods, such as those proposed by Greenbaum and Kyng (1991), which involve discovering what is important to the worker in the existing situation, are important

¹³ The failure to develop a fully automated CIM technological system was an additional key reason for the HC movement to start organising itself towards the promotion of the development of a Human-oriented CIM technological system. This formed part of the efforts to conciliate industrial development through higher productivity and better job and working conditions (cf, Ebel, 1990). As Brodner argued (1987) traditional manufacturing organisation becomes increasingly obsolete and unable to compete in these markets. The continued increase of factory capital intensity, the long lead times caused by functional arrangements and the increasing direct/indirect worker ratio erode the firm's capability to produce high quality/price products in smaller batches.

consideration. Thirdly, the international competition argument stresses that nations need to improve their manufacturing base substantially in order to cope with greater competition from NICs and Japan¹⁴.

In order to locate the HC model within an industrial sociology perspective, it is necessary to differentiate it from other views. The HC concept differs from Kern and Schumann's End of Division of Labour,¹⁵ Piore and Sabel's Flexible Specialisation¹⁶ and Societal effect¹⁷ thesis in terms of its scope and aims. While the HC concept is mainly a general system design philosophy and orientation to be applied at the corporate strategy level, other approaches represent broad socio-economic trends towards different production regimes (Badham, 1991a). This does not mean that the HC concept is limited to the firm level and ignores the socio-economic conditions in which it is applied. Rather, the HC concept is aware of the deep

¹⁴ As a consequence of the adoption of the liberal model political arrangements between nations such as APEC, NAFTA and the EC blocks the financial world markets were deregulated and the further sophistication and accessibility of new technologies occurred. These events were the main cause of what is called new market conditions. These product market conditions involve higher product quality, variety, variability and shorter delivery times, thus allowing production in smaller batches at firm level (cf, OTA, 1991). This type of demand seems to match European labour market conditions as a direct link between product market, manpower skills and work organisation forms exists (Sorge and Streeck, 1988).

¹⁵ Kern and Schumann's (1987) *The End of the Division of labour* interpreted the changes presently occurring in work and management practices as leading to the reprofessionalisation of workers and at firm level the use of a neo-industrialization strategy. In other words, changing the firm's work policies towards a more humane use of labour and a new competitive strategy within the logic of the capitalistic system of production. That is, to obtain higher productivity of labour with the aim of better utilising capital. In low technology areas, the re-organisation of labour has been limited but has broadened the scope of task and transformed the 'simple' industrial activity into semi-skilled activity. A follow up study (Schumann et al, 1990) confirmed their initial ideas. Despite the contraction of the absolute number of (direct) industrial workers, a higher proportion of skilled workers existed, with the 'system regulator' as the new kind of skilled worker being created.

¹⁶ Piore and Sabel's (1984) *flexible specialisation* thesis, argues that the mass production model of industrial development, with its associated micro and macro regulatory institutions, is saturated as a model. Instead, flexible specialisation which combines the use of new technologies with craft work and new sub-contracting arrangements is emerging. They support the view that: (i) new technological developments favour flexible specialisation; (ii) craft work, which links wage and skills enforces short term job security, needs collaborative management/labour relationships and calls for long term job security through monopolisation of skills; (iii) firms need to conciliate competitive and co-operative relations; and (iv) key institutions need to instigate inter-firm co-operation such as regional conglomerates (Italian industrial districts) or federated groups of firms like the Japanese Ziaiatsu.

¹⁷ *The Societal Effect* approach (North, 1992; Maurice, Sellier and Silvestre 1986; Sorge and Warner, 1986) argues that firm performance differences between countries reflect norms and values embedded in and acting upon social institutions. These institutions are composed of actors who can change values and therefore action. Social institutions (Sorge & Streeck, 1988) that regulate the exchange between capital and labour for example, can be approached as a means of explaining a firm's competitiveness in technology intensive products. In this view, the national institutions are approached as the arena where different social actors, at different levels, inter-exchange conflicting and non-conflicting views/rationales/interests and ideologies. It also provides formal and informal societal norms which regulate the above complex interaction. This results in a system which, to a greater or lesser degree, supports industrial competitiveness (Sorge, 1991).

socio-institutional implications of applying particular production models and so considers these in the setting up of new HC-oriented technologies and organisational principles.

Despite the existing criticisms to the above concepts, they can be useful for throwing some light on the role of the HC concept in the current wave of techno-organisational changes.¹⁸ The HC model can be located within the large category of NPCs and has the following features. First, it exists as response to a new type of competition. Second, it works within the capitalistic system of production. Third, it promotes and supports co-operative behaviour among firms (eg, with suppliers and customers) and among management and workers. Fourth, intensive use of AMT is assumed. Fifth, task reintegration at shopfloor level is important. Corbett et al (op cit) suggested that because of the radical propositions of the HC view, it would be an important challenge to develop tools and methods in order to construct a coherent model. Within the spirit of this last statement, the first part of this thesis broads the HC concept by comparing it with key alternative production models, synthesises the core concepts of human-centredness, further develops the organisational dimension of the HC model, and proposes new criteria to assess degrees of human-centredness.

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On the one hand, some key assumptions of the Flexible Specialisation view have been seriously challenged. Claims of the collapse of mass markets, the polarised choice of continuing in the problematic mass markets or the 'switching' of production processes from mass to craft orientation and the view that technological development favours flexible specialisation (overlooking alternatives ways to design and apply technology) are some arguments that weaken this view. Additional counter arguments to Piore and Sabel's Flexible specialisation statements can be found in Hirst and Zeitlin (1991); Pollert (1991); Williams et al. (1987); Blim (1990); Murray (1987); Tomaney (1990).

On the other hand, diffusion of NPCs is not without its problems. The elimination of jobs favouring the highly skilled rather than the less skilled workers, has its disadvantages. The trend of upgrading skills does not automatically lead to better work and career conditions. Additional shortcomings were pointed out by Christis (1988:70-1),

(i) As different production concepts are possible within the same economic rationality, the actual idea of production concepts is too vague to permit a clear distinction between tayloristic and NPC; (ii) theoretically, which dimensions of the old and new production concepts are distinguished and how do they relate ? Can they vary independently and if so, how can we discriminate tayloristic from NPC forms ?; Are they empirical types ? ideal types or normative types ? (iii) regarding logic of development, what is possible ? Concerning dynamics of production concept implementation, which conditions affect the choice of what is possible ? As regards current historical-empirical developments, in which stage of production model dynamics are we ? and finally, (iv) the role played by technological factors seems to be overestimated and the role played by organisational factors seems to be underestimated.

These criticisms do not mean these views are not relevant. Conversely, those approaches seem to be complementary as focuses on different levels of analysis. Firstly, while Kern and Schumann's view emphasised only the qualitative evolution of work structures at shopfloor level, Piore and Sabel's flexible specialisation arguments encompassed both shopfloor and inter-firm relations, networking, as well as its associated institutions. Secondly, the NPC theory, unlike the flexible specialisation theory, does not consider changes in production management concepts as a techno-economic response to market signals, but rather as new forms of restructuring within the framework of capitalistic relations of production (Campbell, 1989).

Human-centred, skill-based or anthropocentric literature has focused on the main characteristics of human centredness for designing, using and developing technology in both design and manufacturing spheres. The HC perspective is a model that while considering specific national settings, proposes concrete guidelines on organisational, technical and human resource management issues and thereby redirects manufacturing strategies and practices towards the redefinition of roles of humans and machines in such a way as to obtain economic and socially sound results. Current HC efforts are going deeper into the shaping of the technical system of production (Corbett et al, 1991), neglecting how a HC manufacturing system as a whole entity would look. We can ask therefore, which criteria must be followed to design, implement and operate a manufacturing system along HC lines at organisational level? How do macro contextual factors influence the application of HC concepts? In the present section, an attempt to integrate a diverse range of literature is made in order to outline how a HC manufacturing system should look.

The HC perspective, by recognising inherent tensions in labour/management relations (Brodner, 1987) at firm level¹⁹ and by recognising market and institutional imperfections at meso/macro²⁰ level, attempts to administrate those technological and organisational factors in such a way as to obtain both technical efficiency and better working conditions²¹. The relative autonomy that workers might enjoy, 'can only be developed within limits which leaves management without fears of losing control over production' (Brodner, 1987: 110).

Although both social and economic conditions have transformed the way in which the work is performed, structural relations between capital and labour remain the same. In traditional taylorist-like manufacturing systems control is performed through direct (personal or

¹⁹

At micro-level, inside the factory, the capitalistic labour process (CLP) guarantees management added value to products through an increased work load and a homogeneous level of output (Brighton Labour Process Group, op cit) The particular way that work is organised in the CLP is not for technical reasons of efficacy but because the way tasks are sub-divided and distributed allows managers to establish a method of production that at the same time enhances the network of power relationships to maintain control over the labour process (Marglin, 1974). However, to execute the above it is necessary to reproduce specific social conditions to guarantee the establishment of the system. The means of production are reproduced through consumption. The workforce is reproduced from outside the firm; salary provides workers with the material vehicle to survive.

²⁰

Educational systems and professional and civic 'consciousness' assure a 'qualified' workforce. This means a diverse skilled workforce, as the technical social division of work requires, is ready to work, technically and ideologically subservient to dominant ideology. The politico-legal (laws and state), and ideological (the different ideologies, religions, ethical, legal, political etc.) superstructure, guarantee the latter (Althusser, 1971). In this way the economic structure and politico-legal and ideological superstructure all combine to contextualise and legitimate manufacturing systems set up and operation.

²¹

The role of the establishment of the participating process for example, is not only for democratic reasons but because it allows the use of unused worker's knowledge and, at the same time, serves managers as a method to legitimate innovation activities (Gebbert, 1986).

impersonal) supervision. Conversely, in the HC view a new type of worker is emerging. Controlled-skilled labour (Manske, 1990) to whom control is devolved, at firm level, via new technologies that allow both technical and organisational decentralisation of operations and further autonomy of workers²². At macro level, control continues being exerted via external customers and market pressures (Pignon and Quertzola, 1974). The HC principles outlined below must be considered within this context.

The corner stone of the HC concept (Brodner, 1987, 1990, 1991; Lehner, 1992; Wobbe and Charles, 1994) is the idea that workers produce goods with the help of machines and not the contrary. The general idea is to redefine roles of human workers and machines in order to respond to product market conditions and, simultaneously, to maintain Western work values. It proposes concrete guidelines to design technical, organisational and human resource dimensions. The core principles of this model are outlined in Exhibit 1.1.

ORGANISATION general guidelines	'Organisational design follows object-orientation rather than function-orientation'; 'Congruence between organisational, technological, socio-political and work related components'
key features	- decentralised production units; - firm within a firm concept; - delegation of responsibility to lower levels; -planning results rather than activities; -task reintegration, group technology, group work
TECHNOLOGY general guideline	'computer used as a tool rather than as a means to replace human intervention'
key features	- machinery able to support task reintegration (e.g. HC-oriented CNC technology, detail scheduling software) at shopfloor level;
SOCIO-POLITICAL general principle	'implementation of HC guidelines is negotiated and does not threaten management control'
key features	-factory reform is not determined only by 'technical' needs, but is subject to political negotiation (ie politics 'of and 'in' production acknowledged); -use of alternative forms of control (eg indirect control by results) that allows workers leeway for self-regulation;

²² This is what Hildebrant (1989) called the 'transparent factory' where through organisational design and use of computer based technology, indirect/on-line control of worker actions, materials flows and outputs occurs.

WORK	
general guideline	'minimum restriction at each work dimension'
Key Features	<p>-<i>Time structure</i> includes both time pressure from outside and the degree to which it is possible for the individual and/or group to plan time management.</p> <p>-<i>Space of movement</i> includes the degree of explicit formalisation of moving from one position to another as a part of the job function.</p> <p>-<i>Social relations</i> refers to the degree of explicit formalisation regarding whom contact and when, as well as the informal possibilities to communicate across or behind the formal structures.</p> <p>-<i>Responsibility and control flexibility</i> concern the scope and degree of responsibility placed on the person or group practice of controlling how this responsibility is managed by the group or individual.</p> <p>-<i>Qualification</i> concerns the functional abilities more or less related to the single job and/or the process of work as a whole.</p> <p>-<i>Stress control</i> includes the degree to which the individual and/or group is able to control the physical and/or psychological pressure that is felt either explicitly or implicitly in the work organisation or man-machine relationship.</p>

Source: Based on Brodner (1987, 1991); Corbett, Rasmussen and Rauner (1991); Wobbe and Charles (1994)
Exhibit 1.1: HCMS: Firm Level Guidelines

These design guidelines include the shopfloor, inter departmental and firm wide level. They emphasise both technical and organisational tools and might be applied individually or collectively. Three additional points should be noted regarding the above guidelines. Firstly, the application of above guidelines has massive implications at firm level for (i) skill formation, training practices and career paths that need to be reformed to support the application of HC principles; (ii) reward systems need be reformed to reflect workers' skills and greater responsibility to meet deadlines and quality standards; and (iii) human resource management, consequently, needs to adapt a corporate culture of co-operative industrial relations and extensive use of participating practices.

Secondly, HC principles are not static and rigid. They acknowledge the importance of adapting these general principles to local conditions where different labour markets, managerial types, labour legislation, education and training institutions exist²³. Furthermore,

23 Within the FAST Anthropocentric Production Systems (APS) research program, a series of report assessing HC principles application have been produced. For the case of Germany see Bandemer, Hennings & Hilbert (1990); for the case of Denmark see Rasmussen, Clematilde & Banke (1990); for the case of France Linhart (1990); for the case of Britain Charles, Roulstone and Charles (1990); for the case of The Netherlands Dankbaar (1990); for the case of Portugal Kovacs, Moniz & Matheus (1990) and for the case of Greece Papadimitriou (1990).

because the HC model is still in its formative stages, the application of the HC model is slow and marginal in European nations. Only a few cases of developed HC production systems exist which have incorporated all core elements of the model (Lehner, 1992).

Thirdly, the above guidelines do not have to rigidly propose one right way to deploy people, technology and organisation. Rather, some criteria items might acquire higher relevance than others, depending on specific national conditions. In the case of Brazil, for example, due to different motives acquisition of advanced computer-based manufacturing technology was restricted up to the early 1990s. As such, design of technology dimension received lower importance than in nations where a high degree of diffusion of that technology exists. Therefore, principles affecting the organisational dimension seem to be more important than use of high technology to the achievement of human-centredness in the specific case of Brazil²⁴.

1.3 CHALLENGES AND OPPORTUNITIES OF HUMAN-CENTRED THEORY

While (organisational) HC criteria above may be a useful guideline for the planning of HCMS, its materialisation in real world situations is constrained due to (i) the fact that the issues of politics 'of' and 'in' production is still far from settled (cf, Brodner, 1987); (ii) the lack of knowledge among industrialists of the existence of a Human-centred model of manufacturing²⁵; (iii) the difficulty of obtaining HC 'designed' technology is still a significant

²⁴ It is important to note that the present examination of HC theory constitutes only one view towards the achievement of HC ideals. Other research programmes, attempting to develop a general system of design philosophy and orientation exist and seem to converge with the HC view. Salerno (1991) pointed out two additional strands.

The first of these strands is the 'macro-ergonomics' research view which incorporates the socio-technical examination of new technology, organisational design and participation issues (Souza, 1994). France's Daniellou (1989, 1990), stresses the study of design of use or work operating forms by examining unexpected and variable events. This methodology claims user intervention as a means to minimising work stoppages by unexpected events. Ergonomic work analysis methodology for example allows to know real human activity in automated systems. This helps in redesigning work and organisation in order to use worker's tacit knowledge. The latter, together formal organisation seems to be key for achieving high work performance (Wisner, 1995, 1992).

Secondly, Italy's movement led by a national Trade Union (FIOM), proposes negotiation with the firm to implement local Trade Union defined work organisation (considering firm operational goals in terms of quantity, quality and lead times). As in the previous case, Trade Union proposals seek to set up a methodology to define both prescript and real work activities (Salerno, 1991).

²⁵ This contrasts to a significant extent with the high diffusion that the 'lean or Japanese' model possesses.

barrier, especially in semi-peripheral nations, and (iv) the significant dependence that the application of specific production organisation principles have on (uncontrollable) macro contextual conditions. Therefore, further studies are called for in order to inform how diverse national settings manage these barriers.

Additionally, because the HC theory is in its formative stages, several gaps exist. The tools to effectively discriminate between alternative Post-Fordist organisational models do not exist. While extensive research has pointed out how to differentiate HC work units, little research exists on how to differentiate HC firms. Volpert et al's (1989) model, for example, is very useful in examining to what extent HC features were applied inside a production 'island'. However, its examination of the extent to which HC principles are implemented at an inter-departmental level and at the level of other important business functions is limited (Bijsterveld and Huijgen, 1994).

Little research has been carried out on networking and its implications for the HC theory. A key question remains unanswered: To what extent do sub-contracting firms have leeway to implement HC principles?, or to pose the question in another way, up to what point does their subordinate condition harness sub-contracting firms to implement HC principles? What about third-tier subcontractors?

Even when recognising the existence of the above barriers to the implementation of HC criteria in manufacturing, to acquire a 'HC' status, a firm does not need to possess a high degree in each factor mentioned in the HC criteria section. Because different nations possess different industrial strategies, they are in different competitive positions and possess different resource endowments as well as indigenous technological capability. Firms in different national settings might be labelled 'HC oriented' if they fill only the 'appropriate' degree of human-centredness in each factor²⁶.

The above comments do not imply that HC theory is lagging behind alternative themes to new production systems. Rather, gaps in the HC theory can be traced to the inadequacy of current theoretical tools for understanding manufacturing systems from a broad perspective. Industrial engineering writers for example, only emphasise how to achieve specific outputs (eg, flexibility) through the application of industrial engineering techniques without considering factors located beyond the shopfloor. These factors include product types and market influences, vocational and training systems and a wider industrial relations environment.

²⁶ Or as Butera (1991) put it, 'a strategy to improve the quality of working life should not be normative or imperative upon each dimension ('the best') but rather should be appropriate ('satisfactory') according to local circumstances'.

Organisational theorists for example, have rightly pointed out general features of organisations under different conditions, but they have failed to integrate meso and macro contextual factors permeating firm level actions while often underestimating the technology issue. Thus, in order to thoroughly understand the processes that permeate the application of the HC model, it is necessary to examine the history of alternative NPS and the wider social context in which they were developed (Kogut, 1993).

The challenge for HC theory is, therefore, to integrate different strands of research and further develop the above-mentioned HC concepts as they need to be crystallised in different national conditions by practitioners and to be fully explained by researchers.

1.4 CONTENTS OUTLINE

In order to tackle the research question from a broad perspective, 3 assessment levels are used in this dissertation (Rauner and Ruth, 1991). First, at the *macro level*, institutional issues that shape firm level actions are examined. The examination of macro factors that support or constrain the implementation of HC principles at firm level is an important component of the assessment.

Second, at the *intermediate level*, of the department and company examination of the degree of human-centredness, concentrates upon the co-ordination of activities, departmental design and the grouping of tasks and functions.

Third, the *micro level* examines the workplace: how the work is designed; to what extent direct workers 'control' their own activities; to what extent firms have restructured their operations along HC lines; and to what extent workers' input in production issues really occurs.

In the theoretical part, different frameworks are used at various levels of analysis in order to better understand the multifaceted nature of alternative industrial organisation models (Morgan, 1990). Macro contextual factors are examined through the lenses of an extended view of the National System of Innovation Approach (Nelson, 1993). At the level of the firm, two approaches were used. While a modified contingency approach (ie processual/configurational model), was applied at the descriptive stage of the research (ie 'how' questions), the social construction of technology perspective was used to attempt to answer 'why' questions. This latter view was also used as meta approach in order to make

sense empirical data collected at the level of the firm with the examination of macro contextual factors.

The empirical part, seeks to explain the dimensions of work and organisation along HC lines. Due to diverse forms of application of HC principles, only case study based research captures their breadth and depth. It allows one to convey information about key social actors and their verification 'in loco'. As part of the case study research carried out for this thesis, a methodological tool was developed and applied to define work and organisational structure features to effectively distinguish between HC and non-HC organisation approaches.

The view sustained in this dissertation is that only integrating both micro and macro level perspectives, would be possible to obtain an approximation of the reality.

Part I examines the theoretical developments of the HC approach.

In Chapter 2 the methodological strategy is discussed and justified. This involves detailing both the research strategy followed and their associated underlying assumptions.

In order to shed some light on the role played by macro institutional conditions that would support or hinder the adaptation of the HC model in semi-peripheral macro conditions, in Chapter 3 a comparative examination between alternative production models (ie, Swedish, German and Japanese) is made in order to localise and qualify the Human-centred model within the dynamics of NPS.

In order to help the analysis of HC organisational and work forms in manufacturing settings, the concept of Human-centred manufacturing Systems (HCMS) is proposed and developed in Chapter 4. Key stages and components of HCMS are examined in this chapter. It includes an analysis of the Manufacturing Engineering System (MES) concept - both its technological and organisational components. Constructivist concepts of technology, organisation and users are applied in order to understand the different configurations that technological and organisational components can take. The strategic congruence issue between technological, organisational and product/market factors is also analysed. The proposed framework differentiates two clear stages of HCMS functioning: the design and the implementation stage.

In the design stage, technological and organisational components of the manufacturing configuration are examined separately. It must be made clear, nevertheless, that the separation is solely a methodological, as they are intrinsically connected. The implementation stage stresses the role of the technology users as well as non-technical aspects of the

implementation process. A model which is used as a base to differentiate HC from non-HC manufacturing systems from the organisational perspective in the empirical research, is developed and presented in this chapter.

Chapter 5 outlines, the HC model from the macro perspective. That is, theoretical considerations are made regarding the role of macro institutional factors during the application of HC principles at firm level. The National Systems of Innovation approach is the base of this analysis. Brazilian macro institutional conditions are examined in this chapter, in order to assess to what extent, socio-institutional factors support or restrict the application of HC principles. This chapter concludes that selected Brazilian macro institutional conditions constrain, rather than support, the implementation of human-centred manufacturing systems.

Part II of the present study empirically examines the extent to which HC organisational principles were applied in selected Brazilian firms. It uses empirical data to assess (i) relations existing between markets, products, productive processes and production models; (ii) relations existing between markets, products, processes and workforce skill levels, reward systems, career paths and training policies at firm level; and (iii) the process of whole firm restructuring using HC principles.

Chapter 6 outlines general features of the researched firms in terms of ownership, market strategy, batch size, product profile and customisation scope. These features are used to discuss organisational design orientations in later chapters.

Chapter 7 focuses on the horizontal dimension of human-centredness. That is, it examines the extent cellular manufacturing has been applied in the researched firms and relates them to three key product features. Namely, product customisation feasibility, cell type and batch size. The goal is to determine whether or not product related features support or constrain the implementation of cellular arrangements.

Chapter 8 examines the vertical dimension of human-centredness. That is, the extent to which firms have adopted cellular arrangements both at shopfloor and firm wide level. Vertical examination demands the development of indicators to measure HC principles application. Three groups of indicators were developed to assess human-centredness at firm level. The first group represents direct control of production and planning activities; the second group measures the extent to which traditional 'indirect' manufacturing activities were performed by direct producers; and the third group of indicators examines the extent to which HC principles were applied firm-wide.

In Chapter 9 an operational criteria is developed and applied to differentiate the firms who restructured work and organisational structures along HC principles from those who applied non HC restructuring. Additionally presented HC criteria are tested to observe its utility; productivity levels and general design orientation are discussed, and Sorge and Streeck's (1988) theory is tested in order to find out whether or not their generalisations can be applied to semi-peripheral nations.

Finally, the conclusion, Chapter 10, outlines the insights of the theoretical and empirical parts of the thesis by restating the forces that constrain and support adoption/adaptation of the HC model. It considers both firm and macro institutional level factors. Products, product markets, labour markets, wider industrial relation systems, production process types, workers' skills, rewards systems, training policies and production models are all considered as essential elements of a manufacturing strategy.

CHAPTER 2

METHODOLOGICAL NOTES

The aim of this Chapter is to provide arguments regarding both research strategy and its underlying research 'logic' applied in order to fulfil with the requirements of the research question and theoretical propositions (Thiollent, 1983; Morgan, 1983; Yin, 1981). It explains what and why particular research methods were applied. Choosing methods²⁷ for researching on organisations and their surroundings is difficult as there seems to be little consensus about how research needs to be done²⁸ (Pfeffer, cited by Sutton, 1997).

The first section details the research strategy followed. Type of method, type of data collection method, criteria for selection sites and data collection process are detailed in this section. The second section, research logic, outlines the implicit assumptions associated to the research strategy explained in the first section. The underlying assumptions of the present research are explained in section three. The last section builds some retrospective comments on methodological issues followed and not followed in the present research.

²⁷ It should be noted that 'method' means general orientation rather than precise instruction on how to proceed. Then space exists for using both qualitative and quantitative evidence.

²⁸ Daft and Lewin (1993) have expressed their concern regarding the need of new methods and non-traditional research for understanding new organisational forms.

2.1 RESEARCH STRATEGY

Because the research question²⁹ is related to the examination of unique events that occur in specific time and space terms³⁰, it is necessary to adopt a comprehensive methodological orientation in order to analyse, explain and interpret the object of research. Therefore, having as the object of research the probable application of the HC model in Brazilian firms and as goals of research, questions regarding the process of adoption, qualitative research methods were used³¹.

Qualitative methods and specifically the Case Study method was used since it allows the capture of the richness and complexity of specific social praxis. Qualitative methods, accordingly Van Maanen (1982) 'represent a mixture of the rational, serendipitous, and intuitive in which the personal experiences of the organisational researcher are often key events to be understood and analysed as data'. Case study has been defined as the examination of a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or few entities (people, groups or organisations). The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used (Benbasat et al, 1987; Yin, 1981). Case study method allows not only the capture of the particulars of the firm profile and key quantitative data³² (eg, bath size and frequency of product change) but also the general socio-institutional environment which studied firms were inserted. That is, case study method seemed to be adequate to capture breadth and depth of application of HC principles as well as its associated contextual conditions. The use of case Study method is justified because theory and research on the use of Human-centred like organisational forms in developing nations yet are in their early stages.

Qualitative methods allow higher flexibility in defining variables, processes to be examined and recognising complexity, exceptions and multiple relationships rather than focusing on

²⁹ The exploration of the feasibility of applying the HC model in a semi-peripheral nation like Brazil and the examination of conditions that shape the HC-oriented firms, are the two aims of this study.

³⁰ That is, the examination of conditions/factors/events that support or hinder the application of the HC model in Brazilian metal mechanical industry in the early 1990s.

³¹ An alternative research strategy is the application of quantitative methods such as survey. Nevertheless, because the examination of the relationships between macro/meso level factors and the firm's profile of adoption of HC concepts seems to be central to explain the process of adoption, the use of qualitative methods seems to be more appropriate than quantitative ones. Additionally, because of its exploratory nature, the present research does not look for test or statistically validate specific trend, a task which is adequate for quantitative research methods.

³² That is, quantitative methods were used not as strategy of research but as one of the multiple techniques for data collection within the (qualitative) case study method.

regularities, cause-effect relationships and classifications. Higher flexibility, in turn, improve chances to capture new insights, a crucial goal of qualitative research.

'When the goal of qualitative research is theory development, the "significance test" for assessing its quality may seem like it should be restricted to whether or not new, interesting, and logical insights are developed. Concerns about whether or not design and analysis are rigorous enough to confirm such insights may seem irrelevant. After all, the intended product of such research is new insight, not a test of those insights. The open-ended and flexible methods that seem best suited for testing new insights may seem to be poorly suited for testing the reliability, validity, and generality of those insights.' (Sutton, 1997: 99).

The research strategy used is an 'Exploratory' case study since the studied problem does not have a well established theoretical base, the research question entails the study of a unique little known event, there is very little available research on this topic and, as pointed out in the theoretical part, the contextual conditions seem to play an important role in the application of the HC model. Therefore, the present research looks for providing initial explanation for understanding the process of application of HC concepts in the Brazilian national setting.

Although qualitative methods are not significant from the statistical perspective, they can be considered 'representative' in qualitative terms. Michelat (cited by Lima et al, 1997) pointed out that the diversity of the 'sample' and the wide range of dimensions examined favours an heterogeneous view of the phenomenon studied. This precisely seems to be the strength of the methodological strategy used in the present research. Established knowledge on both the use of HC concepts in highly industrialised nations and on the historic development of the industrialisation process of Brazil, adds qualitative 'significance' to the present research. Therefore, the present research can be considered 'exploratory' on a higher level.

An additional critical design question regarding methodology, was to choose between single versus multiple case design. Multiple case study design was selected because the single case study provides little chances for finding firms which could be qualified as HC type. If this were the case, the research question would be annulled. Additionally, considering the theoretical insights of Chapter 3, new production systems ought to be understood within their specific contextual conditions. Therefore, multiple case study design favoured the comprehension of new organisational forms from a wider perspective since allowed comparative examination of sites with different market, technical and contextual conditions (Benbasat et al, 1987).

Differently from single case study research, cross case study research allows greater generalisation of research results since it supports the inclusion of a range of conditions under a broad perspective. Yin (cited by Ellram, 1996) has suggested that the generalisation of case study results tend to be qualitative since "the investigator's goal is to expand and generalise theories (analytic generalisation) and not to enumerate frequencies (statistical generalisation)".

Research experience (Ellram, 1996) has suggested that between 6 and 10 cases might provide evidence to support or reject an initial set of propositions. It should be noted that the amount of data for performing qualitative research is difficult to define as large qualitative data would help to produce interesting and detailed descriptions but not necessarily high quality resulting insights. (Sutton, 1997). Because there is very little evidence of application of the HC model in Brazil, the 10 cases were chosen selectively. Suggestions from industry practitioners, academic researchers and specialised media helped to select the firms, targeting firms that might apply HC principles.

Types of data collection techniques used: Multiple means to collect information used in order to avoid simplistic polarised situations such as the HC versus non-HC cases. As explained in the theoretical part, because of its configurational nature, the HC model can be implemented in a wide variety of forms. Therefore, structured observation applying direct observation; semi-structured interviews and; scales for rating were the main research instruments used since they seem to be adequate for fulfilling the features of qualitative research³³.

Direct observation was crucial to determine whether or not a firm apply the HC model since the research question entailed not only specific 'objective' issues. Rather, there were many subjective issues which assisted the assessment of the depth and breadth of HC principles application. For example, the worker-management relationship, a key factors for explaining the level of worker 'participation' can only be captured in-locus. Because of this, field work was performed by the author of this dissertation, who personally visited all the researched sites, observed productive processes, conducted interviews and applied questionnaires.

Semi-structured interviews were applied in order to assist the systematisation of data collected in order to maintain a coherent body of data as well as to ensure the key information supplied³⁴. Semi-structure interviews helped to maintain a set of common points in order to avoid data dispersal while considering the individual features of each firm. It also allowed to pursue new lines of questioning when necessary. Interviews were highly flexible as different firms have different production processes and so different key areas. In 95 % of the cases, the

³³ Need to be recognised that all techniques might introduce distortions regarding the representation of 'reality' (Thiollent, 1985). Then, as explained in the following section, the underlying assumptions of the methodological strategy were considered and special care was taken during the data collection process inside the firms. The latter was to keep the coherence between the goals of research, methodological tools applied and the research theoretical framework.

³⁴ See in Appendix "A" an outline of the questionnaire used for assisting the semi-structured interviews.

top person responsible for specific areas was interviewed. As above mentioned, additional visits to specific areas or interviews to additional persons occurred.

Scales for rating were used in order to systematically obtain an idea of the degree (ie, depth) a particular factor was really occurring. Using scales for rating different factors enabled transcend the traditional 'low', 'medium' and 'high' categories. Scales used were important as this instrument allowed the systematisation of data in the cross-case analysis. Ordinal scale was used in order to 'rank in an ordered series with respect to the degree to which they possess a certain characteristic' (Carneiro, 1970; Ember, 1970: 702). While in some cases it was possible to establish exactly the extent to which specific features exist, in others it was not possible as the factor under examination was of strict qualitative nature so it did not exist a physical unit of measurement in order to replicate them. Because the number of factors examined at each case study was high, a 'radar' scheme was used to represent a set of factors. Despite a score was set up for each factor, it does not represent an accurate measure. It represents a particular degree of occurrence of specific factor under the subjective lenses of the evaluator only. In other words, each set of ranks is an estimate of their order. Nevertheless, scores attributed to different factors seem to be reliable as the same evaluator assessed all industrial sites using the same research instruments and the same (subjective) criteria.

A methodological tool was developed and applied to define work and organisational structure features (ie, intermediate and micro level) to effectively distinguish between HC and non-HC organisation approaches. A particular characteristic of the present study is that, purposively, the narrative section of each case study was omitted in order to focus efforts on the analysis and synthesis phases.

Data collection Process: In order to obtain accurate and consistent data in the multiple case studies, the author of this dissertation personally performed the data collection phase. That is, he personally applied the semi-structured interviews, visited plants and observed manufacturing processes, organisational practices and management styles. This involved visits to all industrial sites, personal interviews with key staff from different hierarchical levels (see Exhibit below), informal conversation with other staff (including production workers), and examination of company documents supplied both formally or informally by the interviewees. Moreover, in order to assure accurate data, a triangulation process was performed. That is, the key information provided by an interviewee was checked either by another one and double-checked during the plant tours either by directly observing specific event or by asking personnel directly involved in the operation (ie, supervisor and/or direct operators).

FIRM	TOP MANAGERS	MIDDLE MANAGERS	SUPERVISORY PERSONNEL	SUB-TOTAL
Cla	4	3		7
Emb	3	4	2	9
Vil	4	5		9
Sie	4	3		7
Wab	3			3
Osa	2	1		3
Yan	1	1	1	3
Weg	5	1	1	7
wor	2		1	3
MI	3	3		6
			TOTAL	52

Exhibit 2.1 : Number of persons formally interviewed

Based on supplied information of the key research points, visits to industrial plants were scheduled by the firm's host person but the researcher had enough freedom in all the firms to both interview additional persons and visit additional productive areas, including free time to return for additional information. Data collection occurred in March and April 1993. Visits to industrial sites and interviews lasted between 3 and 4 full days, at each firm. Formal interviews lasted between 15 minutes and 2 hours. The number of informal interviews varied in significant extent depending on the openness of the firm, but they were approximately 12, and as in the case of formal interviews, involved from top managers and directors to shopfloor workers.

Selection of sites: The HC model is being applied in core European industries as an answer to the Japanese threat. This means that the HC concept was idealised and developed to meet specific needs of leading European core industries. An important industrial sector in which HC concepts are used is the German metal-mechanical sector (engineering firms). In order to test the feasibility of using the HC concept in a different setting, and, if so, to map possible paths of utilisation, case studies were carried out in Brazilian firms. Because Brazil is considered a mass-producer nation, HC type firms would be unlikely to exist. The selection of research sites therefore included firms in which the probability of applying HC concepts were high.

There was a non-random selection of firms. In order to have a representative (ie heterogeneous) sample, selected firms had to fulfil some requirements in terms of ownership, geographical location, batch size, output volume, type of production process and industry sector. This heterogeneous sample would allow the better exploration of the feasibility of applying HC concepts in firms which possess different product and market profiles from European exponents of HC manufacturing.

Potential firms to be researched had to fulfil two additional requirements. First, the firms needed to be advanced users of new organisational forms. High technology intensity in production processes was not necessarily a basic pre-requisite. However the firm's output needed to embrace a high technological content level. Second, firms needed to produce in batches. Application of some types of advanced organisational arrangements, like cellular manufacturing, are better observed and found in firms involved in discrete manufacturing activities such as metal-cutting operations³⁵. Advanced cases of firms following HC orientation exist in this type of industry, in industrialised nations (cf Kidd and Karwowski, 1994).

Because of its novelty, it was expected that only leading-edge firms would have the capacity to apply HC concepts. Then, research sites were looked for only in the southern States of Brazil, the most industrialised region. The fact that researched sites were located in southern states was positive for the research as macro institutional conditions in Brazil are highly heterogeneous. Northern states have deficient and insufficient macro structural conditions while southern states possess better macro structural conditions. The above profile was filled by firms of the capital goods industry and automobile suppliers. In both cases the technological base was metal cutting activities. While selected firms were heterogeneous in size, ownership, market targets, and batch size, they have high probabilities of HC concepts being applied³⁶.

Having justified the key methodological choices made, the next section outlines implicit, subtle reasons that underlined the researchers assumptions during the design and development of the research.

2.2 RESEARCH LOGIC

Qualitative research requires capacities for making evaluations, recognising new patterns and creating new symbols to describe it. In order to perform these activities the researcher uses his/hers own value systems. This means that the act of performing such cognitive activities is not value-free (Blackler and Brown, 1978; Morgan, 1983). Because the researcher's view of the world influences the outcome of the research, it is important to explain the assumptions

³⁵ Nearly 75 % of the value-added in this industry is generated in small and medium size batches (Ayres et al, 1985:90).

³⁶ For a detailed description of selected firms, see Chapter 6.

and values embedded in the research approach used. This implies explaining the assumptions about the nature of science and about the nature of society. Burrell and Morgan (1979)'s theory for analysing social theory supply the framework to differentiate "paradigms" for analysing social theory³⁷. Their central idea was the view that "all theories of organisation are based upon a philosophy of science and a theory of society" (p. x).

Assumptions about the nature of Social Science are important because the extend to which social science can be approached as objective or subjective is directly informed by the researcher's assumptions about the nature of social science. Those assumptions are related to ontology, epistemology, human nature and methodology.

Ontological assumptions concern the nature of the object of study. There are two polar interpretations. In the first one, realism, "reality" is viewed as external to the individual (ie, given). This implies "that the social world external the individual cognition is a real world made up of hard, tangible and relatively immutable structures" (p. 4). Therefore, the object of study can be approached as "objective".

In the second one, nominalism, "reality" is viewed as a product of the individual's mind. That is, "the social world external to the individual is made up of nothing more than names, concepts and labels which are used to structure reality" (p. 4). Then, the object of study can be approached as "subjective".

Epistemological assumptions relate to assumptions about the grounds of knowledge. For example, whether knowledge is something hard, real and possible of code and decoded in order to be communicated in a tangible way or whether knowledge is something soft, tacit and then difficult to code and decoded in order to transfer it. So it is approached as unique to the individual.

In the former case, positivism, the individual interprets the social world "by searching for regularities and causal relationships between its constituent elements" (p. 5). This approach is widely applied in the natural sciences. In the latter case, anti-positivism, the individual interprets the social world as "... essentially relativistic and can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied" (p. 5). Then social science is viewed as subjective by definition.

³⁷ It should be noted that this is not the unique way to frame social science and specially organisational science. Despite the existing critics to Burrell and Morgan's work, their framework is useful to locate particular strand of research and to put some "order" in the contested, pluralistic and somehow extreme positions of organisational studies. (cf, Burrell, 1996).

Assumptions about Human nature relate to the way individuals interpret their relationship between them and the environment. On one hand, determinism perspectives in social sciences "entail a view of human beings responding in a mechanistic or even deterministic fashion to the situations encountered in their external world" (p, 2). That is individuals are approached as product of the environment and so conditioned by it. On the other hand, voluntarism view approaches individuals as builders of their environments. That is individuals are viewed by some social sciences as autonomous and free-willed. Burrell and Morgan suggest that the understanding of assumptions about human nature are key for helping to understand social science theories since they point out the broad relationship between man and society.

The three set of assumptions above directly influence *methodological* issues of social science. "Each one has important consequences for the way in which one attempts to investigate and obtain knowledge about the social world. Different ontologies, epistemologies and models of human nature are likely to incline social scientist towards different methodologies" (p, 2). There are two extreme methodological approaches to social science, the ideographic and the nomothetic.

The ideographic approach, accordingly Burrell and Morgan, "is based on the view that one can only understand the social world by obtaining first-hand knowledge of the subject under consideration. It thus places considerable stress upon getting close to one's subject and exploring its detailed background and life history. The ideographic approach emphasises the analysis of the subjective accounts which one generates by 'getting inside' situations and involving oneself in the everyday flow of life" (p. 6).

The nomothetic approach stresses the use of systematic protocol and technique of research methods. "It is epitomised in the approach and methods employed in the natural sciences, which focus upon the process of testing hypothesis in accordance with the canons of scientific rigour. It is preoccupied with the construction of scientific tests and the use of quantitative techniques for the analysis of data. Surveys, questionnaires, personality tests and standardised research instruments of all kinds are prominent among the tools which comprise nomothetic methodology" (p. 6-7).

Burrell and Morgan (1979) suggest that the extreme positions of each one of the four strands are reflected in two widely used strands of research. First, positivism, "reflects the attempt to apply models and methods derived from the natural sciences to the study of human affairs" (p. 7), treating the social world as if it were the natural world. Second, the German idealism, which "is based upon the premise that the ultimate reality of the universe lies in 'spirit' or 'idea'

rather than in the data of sense perception" (p. 7). Both positivism and German idealism define the objective and subjective extremes of Burrell and Morgan's model. Next, an explanation of the assumptions underlying the nature of society is outlined.

Assumptions about the nature of Society: Burrell and Morgan's second dimension that help to understand the underlying logic of specific research is the "regulation-radical change" distinction³⁸. *Regulation* "...is essentially concerned with the need for regulation in human affairs, the basic questions which it asks tend to focus upon the need to understand why society is maintained as an entity. It attempts to explain why society tends to hold together rather than fall apart" (p. 17). So, sociology of regulation emphasises upon social cohesion and solidarity which characterises Durkheim's "order" views of the world. Stability, integration, functional co-ordination and consensus would be the ground nature of society under this view.

The Radical change view of society seeks to "find explanations for the radical change, deep-seated structural conflict, modes of domination and structural contradiction which its theorist see as characterising modern society... The basic questions which it asks focus upon the deprivation of man, both material and psychic. It is often visionary and Utopian, in that it looks towards potentiality as much as actuality; it is concerned with what is possible rather than with what is; with alternatives rather than with acceptance of the *status quo*" (p. 17). The work of Marx is an example of this view.

Like in the previous dimension, research usually falls in the continuous line between these two views of society. And the outcomes will inevitably be influenced by the researcher's adopted view of society.

Using the subjective-objective and the regulation-radical change dimensions, Burrell and Morgan defined four sociological paradigms for assisting in the examination of the assumptions and values embedded in different social theories (see Exhibit below). Accordingly Burrell and Morgan, those paradigms are 'defined by very basic meta-theoretical assumptions which underwrite the frame of reference, mode of theorising and *modus operandi* of the

³⁸ The 'regulation-radical change' distinction adopted by Burrell and Morgan is based on Durkheim and Dahrendorf. While the latter sharply pointed out dichotomy 'order' - 'conflict' theories, Burrell and Morgan adopted the proposed 'regulation-radical change' view because of the problems of potential misinterpretation found in the 'order-conflict' views. For example, the notion of 'conflict' was approached as an integrative mechanism to explain 'order'. This view is totally against macrostructural forms of conflict such as class conflict and war. Problems were also pointed out in the *consensus* versus *coercion* dichotomy. Consensus might be obtained throughout the use of coercive force. Then, shared values might reflect not only degree of integration but also the success of the forces of domination.

social theorist who operate within them' (p. 23). Using this framework in the next section the present research approach is located in order to turn explicit their underlying assumptions³⁹.

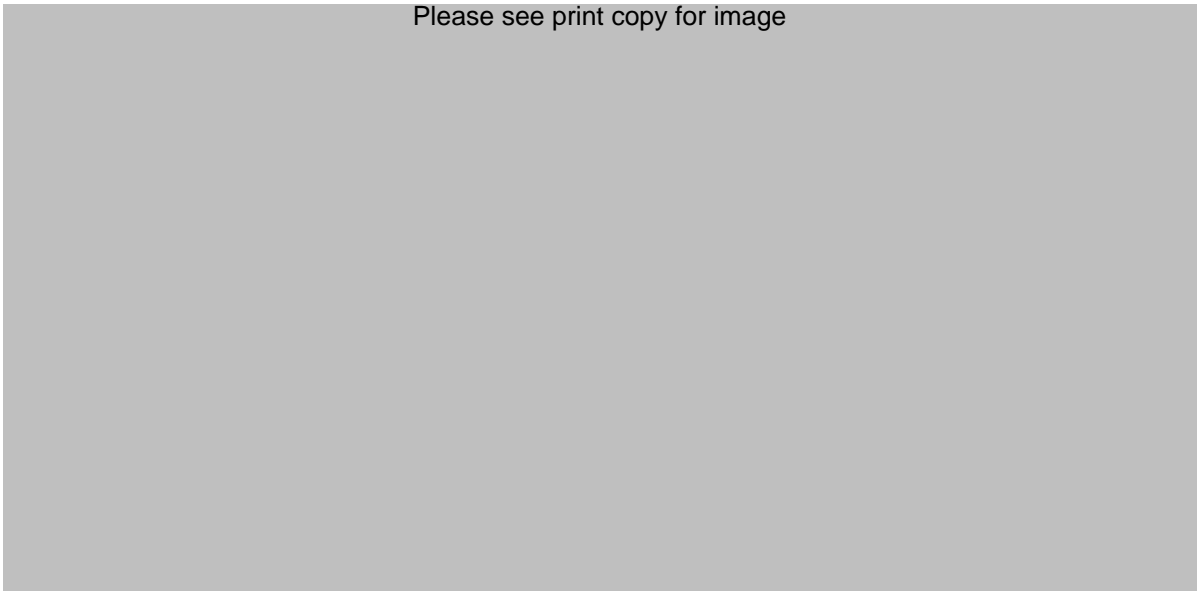


Exhibit 2.2: Four paradigms for the Analysis of Social theory
 Source: Burrell and Morgan (1979)

2.3 THE UNDERLYING ASSUMPTIONS OF THE PRESENT RESEARCH

In order to be aware of the underlying assumptions of the present research, it is necessary to differentiate between :

³⁹ Burrell and Morgan's framework however can be interpreted not only to as a theory of knowledge: "It was a means to carve out a protected niche where 'alternative' researchers could do their thing, protected from the criticism of functionalism, free from what they saw as the necessity of having to try to explain their work to them. The key to this defensive strategy lay in the 'incommensurability' of the paradigms and the language that precluded communication among them....The issue is not one of epistemology, logic or linguistic theory, it is one of politics: those defending incommensurability believe it to be the best way to protect alternative approaches from the continuing onslaught of mainstream approaches in their various and evolving forms; while many of those who attack it believe it to be counterproductive in such a defence" (Clegg and Hardy, 1996). Moreover, there seems not to exist consensus in the academic community regarding which paradigm is the 'right' one. Pfeffer (quoted by Clegg and Hardy, 1996) has suggested that what constitutes consensus in a scientific field is a political affair: "My sense is that such consensus was developed by a group of individuals forming a dense network of connections and unified view, who then intentionally and systematically took over positions of power and imposed their views, at times gradually and at times surreptitiously. There seems to be nothing in the natural order of things that suggests that mathematical rigor should be valued over empirical richness or realism. Rather, the criteria, the status hierarchy, and the enforcement of rules were and are very much political processes" (p, 6).

1. The underlying assumptions of the research method used;
2. The underlying assumptions of Human-centred theory;
3. The underlying assumptions of the social construction of technology perspective;
4. The underlying assumptions of the researcher.

Before preceding to explain the above mentioned underlying assumptions, in the next section the functionalism approach is further detailed since it is within the functionalism approach that a significant part of the research method was developed. Specifically, the a modified contingency perspective was applied on the descriptive stage of the research (ie, "how" HC concepts were applied in Brazilian industry), and the social construction of technology view was applied at explanatory stage (ie, "why"). Because the research question relates to the application of HC concepts, it is also necessary to make explicit assumptions embedded in HC theory.

The Functionalism Approach

Functionalism approaches its subject matters as objective and assumes that society looks for social order and cohesion. That is, it is clearly in the 'objective' and 'regulation' quadrant of the Exhibit above. This means that it is concerned with looking for arguments to explain social order, status quo, consensus, social integration, solidarity and needs satisfaction on one hand. On the other hand, it assumes that 'the social world is composed of relatively concrete empirical artefacts and relationships which can be identified, studied and measured through approaches derived from the natural sciences' (Burrell and Morgan, 1979: 26). This way of approaching society and the nature of science however is not static. The functionalism paradigm has been influenced by the German idealist traditions and Marxists theory, emerging a variety of functionalism approaches. Burrell and Morgan (1979) distinguished four: On one extreme, *Objectivism* which applies natural sciences views⁴⁰. Besides objectivism, *Social systems theory*, derived from the pure positivism views (ie, applying biological and mechanical analogies to explain social issues), and represented by structural functionalism and systems theory. On the other extreme, *Interactionism* and *social action theory* which are nearest to the subjectivist boundary as combines positivism with German idealism. In the middle, *Integrative theory* seeks to bridge the gap between social system theory and interactionism.

Within the functionalism approach there are different strands which basically differ in the degree to which are more objective or less objective (ie, near the subjective axis of Burrell and

⁴⁰ It involves behaviourism (which is derived from physiological models employed in psychology) and abstracted empiricism (which is dominated by quantitative methodologies).

Morgan framework) and closer to the 'regulationism' view or closer to the 'change' view of society. The idea of 'pluralist' versus 'unitary' views synthesises these strands.

The Pluralist view stresses the pluralist nature of interests, conflict and sources of power that occur in the organisation. Accordingly Morgan (1986: 185), "The pluralist vision is of a society where different groups bargain and compete for a share in the balance of power and use their influence to realize Aristotle's ideal of politics: a negotiated order that creates unity out a diversity".

The pluralist view can be better explained contrasting it with the 'unitary' view regarding three dimensions: interest, conflict and power. While the unitary view stresses the co-operative and unified nature of organisational goals, the pluralist view stresses the diversity of individual, group and organisation goals. Conflict, to the unitary view is a rare phenomena that can be removed through managerial action. Conversely, to the pluralist view conflict is an inherent organisational feature. Pluralist managers seek to work out conflict in such a way to promote a positive outcome to the whole organisation. Regarding power, the unitary perspective simply ignores power issues in organisational life. Authority, leadership and control are approached as neutral resources. The pluralist view approaches power as a mean to address conflict (Morgan, 1986).

Using both Burrell and Morgan's framework to analyse social theory and Morgan's (1986) framework to distinguish different strands within the functionalism area, in the next sections the underlying assumptions of the method of research applied, theoretical framework developed and the researcher's assumptions are detailed.

Underlying Assumption of the research method used

The present research used the functionalism approach from a broad perspective. That is, while using central concepts of the functionalism approach, there have been considered its shortcomings and limitations. More specifically, the present research can be located within social systems theory (that involves structural functionalism and systems theory), using some concepts of the Integrative theory.

The key concern of the present research is to understand what was occurring when firms tried to apply the HC model and how this process has occurred, from a broad perspective. Functionalism approaches are useful to establish how a specific event is influenced by a set of others. Functions and roles of key social actors and firms characteristics are examined in order to assist the understanding of how the process occurs. Nevertheless it needs to be

acknowledged that clearly defined rules for examining relations does not exist. Functionalism approaches do not look for simple cause-effect relations among intervening factors. Rather, the idea is to locate, assess and qualify factors that are crucial in assisting the understanding of the research question as well as to shed some light on the key relations among them (Boudon, 1983).

For example, two key characteristics of the functionalism approach were applied at the firm level of analysis. First, because of the exploratory nature of the present research, it was necessary to understand the likelihood for applying HC concepts in a totally different macro institutional setting. Then, the need to search for key features of the HC approach in the Brazilian setting as well as the functions they perform emerged in the first place in order to attempt to explain how it happens.

Second, along the open systems perspective, organisations were conceptualised as networks of relations between the constituent parts. So, Mintzberg (1979)'s configuration ideas for example, were used as an elaborated form of the contingency model. It was useful to examine interdependencies among diverse organisational, technical and people related elements, and, specially, to aid to capture a landscape view of the problem. Building on positivism assumptions, Miller and Mintzberg (1983) emphasise synthesis over analysis in order to identify clusters of attributes called configurations. Configurational approaches allow the examination of a large number of attributes in order to yield a detailed, holistic, integrate image of reality; support the finding of common natural clusters; search for networks of causation rather than for simple unidirectional causation between pairs of variables; consider time and process, and; combine both quantitative with qualitative data in order to help to explain findings⁴¹.

Additional views and approaches that not necessarily fit the functionalism approach were also used in order to address some of the limitations and shortcomings of the functionalism approach. First, a processual view of organisation was adopted in the theoretical part since 'in human society the social structure as a whole can only be observed in its functioning' (Radcliffe-Brown cited by Burrell and Morgan, 1979). This allows to overcome the organisms

⁴¹ Mintzberg (1982: 115) put simple and strong arguments for defending his own 'direct research' strategy: "research based on description and induction instead of implicit or explicit prescription and deduction ('It is discovery that attracts me to this business, not the checking out of what we think we already know'); reliance on simple, inelegant, as opposed to "rigorous" methods of data collection ('what, for example, is wrong with samples of one ? Should Piaget apologise for studying his own children, a physicist for splitting only one atom ?'); the measurement of many elements in real organisational terms, supported by anecdote, instead of few variables in perceptual terms from a distance; and the synthesis of these elements into clusters, instead of the analysis of pairs of variables as continuous relationships".

view that organic structures can be studied independently of their functioning. And this is not the case of societies.

Second, an important limitation of functionalism relates to the view that societies are able to change structurally and organisms do not. The present research applied some ideas of the sociology of radical change perspective in order to contribute for explaining how 'change issues' occurred during the application of HC principles in Brazil. That is, despite organisation stability and functional integration are key aims for correct functioning of the organisation (ie, to be competitive), at the societal level however, the theoretical proposals of this dissertation acknowledged that social conflict exists (such as class conflict) and that structural change is a constant of societies.

Third, the functional unity hypothesis of the functionalism approach was not followed because the present research approaches organisations as a place where converge individuals and groups (both internal and external to the organisation) which possess different views, interests and motivation. So the present research recognises potential conflict is a constant component of organisational life.

Underlying Assumptions of Human-Centred Theory

Human-centred theory is based on socio-technical theory which in turn was influenced by early industrial psychologist studies (such as the Hawthorne studies), job design theory, Quality of working life movement and Contingency theory. Those early theories clearly perform within the functionalism approach. That is, roughly speaking, all them are based on assumptions of order and regulation. It should be recognised however, that these theories possess different degrees of order and disorder, consensus and dissensus, solidarity and conflict and social integration and dis-integration⁴². In what follows the assumptions underlying some of the main theories from which the Human-centred approach drawn are outlined.

Socio-technical systems theory, can be regarded as a foundation stone of HC theory. The Socio-technical systems approach has its roots in Ludwing Von Bertalanffy's (1950) open systems concept. That is, production is made up of sub-systems that are inter-related and congruent. Additionally, the system is 'open' to its environment in terms of achieving an

⁴² For example, while the Hawthorn studies clearly applied the idea of open systems in equilibrium, latter physichologist turn their attention on the relation between work, satisfaction and performance, searching for causal relations between these variables. Because research found little relationship between these variables, the attention was turn towards the understanding of motivation of work (cf, Herzberg et al, 1959).

'appropriate' relation with it in order to survive. Tavistock's socio-technical approach investigates the relationship between work and technology in order to increase both productivity and job satisfaction. Tavistock researchers were looking for 'joint' optimisation of technical and social needs. The Parsonian functionalism rationality is used to explain the open system function (Morgan 1989; Brown, 1992).

The main contributions and limitations of the socio-technical perspective have been pointed out by Brown (1992). Contributions of the socio-technical theory are derived from the understanding of the linkages between organisations and their environment and from a recognition of the existence of a wide range of options to achieve 'joint' optimisation between work and technology. The assumption regarding intrinsic sources of individual work satisfaction (ie, task variety, discretion, autonomy and recognition) provide a powerful analytical tool with which to assess industrial organisations.

Some of the limitations of socio-technical theory include: (i) despite its emphasis on understanding organisations and their environments, a narrow view of environment is applied (ie the environment is regarded as product markets and culture); (ii) it fails to acknowledge capital/labour conflict of interest, that is, political and power issues permeating the employer/employee relation are largely ignored; (iii) bias towards a managerial perspective reflected in the emphasis on consensus and integration⁴³; and (iv) although claiming 'joint' optimisation, social organisation is often fitted to existing technology. Excluding such exceptional experiments as that at Volvo Kalmar, technology was treated as a given⁴⁴.

The above suggests that socio-technical theory adheres to regulationism and order view of social science and nature of society. The final goals for improving working conditions and technical efficiency of the 'production system' were to achieve social harmony, integration and maintain the status quo through job redesign.

Building on the shortfalls of the socio-technical approach, *contingency theory* recognised the importance of the environment and the need for searching interrelationships between different aspects of the environment, structuring and functioning (Brown, 1992). The key assumption of contingency approaches is that organisational effectiveness is reached throughout the

⁴³ For Emery and Thorsrud, for example, changes in the individual job were focused more on the improvement of working conditions than on the increase of any worker participation. In Norway, socio-technical theory influenced the early stages of the industrial democracy movement in such a way that, 'the notion of industrial democracy was depoliticized by focusing at technology and the organisational control system as the main factors obstructing a change to a more democratic organisation' (Bolweg, 1976: 90).

⁴⁴ Latest socio-technical theory developments (cf Butera 1995), however, are addressing some of this shortcomings.

achievement of 'congruency' between the different elements of the organisational subsystems. Contingency theory clearly applied organic analogies (cf, Burns and Stalker, 1961), a key dimension of functionalism theories.

Contingency theory therefore, falls neatly within Burrell and Morgan's sociological functionalism paradigm. The contingential approach is widely used in organisational studies since it provides a set of finite analytical tools for examining organisations. Donalson (1996) argues that contingency theory constitutes a coherent approach for studying organisations since it has become 'normal' science (cf, Khun, 1970): there is already an accumulation of empirical results that supports consensus building and theory development regarding what is and how it works an organisation. To Donalson, contingency theory will remain the core explanatory theory of organisational structure since new approaches (eg, transaction cost theory, institutionalism and agency) would supplement rather than substitute contingency theory.

Contingency theory nevertheless has the same associated problems of the unitary view: technological determinism, linear cause-effect view of human relations affairs, hierarchical establishment of areas to be researched and problem to be solved and failure of management theorist to solve contemporary business problems, among others (Clegg and Hardy, 1996; Marsden and Townley, 1996). A main problem with contingency approaches, Burrell and Morgan pointed out, lies in the way 'process' and 'structure' are operationalised: the process of organising is usually equated with structural features such as size and technology. Then, it does not exist congruence between theory and the method very often. A similar problem was experienced in the present research⁴⁵.

The *Quality of Working Life* movement (QWL) is based on insights from open systems theory, socio-technical systems and theory of job design. It has a strong social component since it was originated in the Scandinavian countries which have strong democratic traditions. Then, despite having roots in traditional functionalism organisational theories such as socio-technical systems and contingency approach, it departs in some ways from traditional functionalism. The QWL movement constitutes one of the fundamental stones of Human-centred theory. The QWL meta-goal was to achieve social equality with economic efficiency. This means that national economic rationality was subordinated to this higher level goal. In order to achieve it, a series of government, meso and firm level mechanisms were introduced.

⁴⁵ Within contingency theory other approaches were developed. Child's *strategic choice* approach for example, argues that there is room for choice in organisational developments. The dominant power coalition, in this case, has power to influence the choices made.

At the firm level, mechanisms developed⁴⁶ involved the search for new knowledge, techniques, and experiences. Burrell and Morgan have detailed how QWL departs from traditional functionalism concepts:

Viewed within the context of the contingency model... the quality of working life movement urges a programme of organisational change based upon the assumption that a more humane working situation is a functional imperative within the context of the system as a whole. The argument is that social change within the wider environment is such that people are beginning to demand more satisfying work, and that organisations need to make operational and managerial subsystems congruent with these demands ...Its propositions run counter to those of contingency theory, which stresses that in stable environments rigid, dehumanising work structures may be appropriate for achieving organisational effectiveness ... the view propounded is essentially that it is a functional imperative that the quality of working life be improved to sustain society as a whole. The notions of 'social responsibility' and 'individual responsibility' are often summoned to bridge the gap between organisational or personal interests on the one hand and societal interest on the other. Social responsibility thus become a functional imperative as far as the maintenance of the social system as a whole is concerned' (p 182-3).

Therefore, QWL movement is regulative since the application of socially sound organisational forms is aimed towards the stability and survival of the whole system, Burrell and Morgan noted. From the QWL movement derived the German 'Humanisation of work' program.

Humanisation of Work (HoW) was a Government sponsored research program developed in the 1970s in order to improve working conditions as mean to cope increasing problems of absenteeism and recruitment. The HoW program, focused on the promotion of psychophysical health and psychosocial well-being of individuals through the development of qualifications in order to allow collective influence on work conditions and to the development of his-her personality (Ulich, 1989). Like the QWL movement the HoW program can be qualified as regulative. Although there was a shift in perspective away from unitary views, the main concern was clearly managerial : improve working conditions in order to maintain the status quo.

Industrial Democracy was another key approach from which the HC approach was based. It has links with the QWL movement and involves a 'pluralist' view of society. The concept of Industrial democracy recognises, on one hand, the existence of different groups, individuals with different interests, goals and values. On the other hand, it notes that worker's interests are not adequately represented in the organisational decision making process. So there is an attempt to develop stronger worker participation on the firm's decision making process. Nevertheless, should be noted that different levels of decision making exist. While direct participation is generally restricted to the individual and work group level, indirect

⁴⁶ Macro and meso level mechanisms are outlined in Chapter 3 (see section 'The Swedish model').

participation occurs through elect representatives who look after the worker's interests at the higher organisational and supra-organisational levels (eg, national, industry and company level)⁴⁷. Norway's Co-operation Project was an exemplary case in which different approaches towards industrial democratisation were applied: from shopfloor initiatives to workers organised views at national and industry level⁴⁸. The industrial democracy movement seems to be the most pluralist of the approaches which inform Human-centredness.

Job redesign was a key mean to promote change both at shopfloor and firm level in socio-technical theory, QWL movement, Humanisation of Work program and industrial democracy initiatives. Job redesign nevertheless, might have different outcomes depending on the approach applied. Job redesign, for example, 'can only be labelled work democratisation if workers and their representatives influence the redesign process, if the changes lead to increased autonomy of the worker and if workers share the possible economic benefits of the changes' (Bolweg, 1976: 108).

In summary, despite their different goals and assumptions, theories informing the HC approach can be located, in different degrees, away from the unitary view and near the pluralist perspective. This partly explains why the HC approach can be considered as pluralist within the functionalism paradigm.

Underlying Assumptions of the Social Construction of Technology

While HC theory is based on functionalism theories, the meta approach used in this research, the social construction of technology, departs in important points from the rough functionalism assumptions.

The social construction of technology approach can be located within the field of Science, Technology and Society (STS) which has focused in two specific areas related to the sociology of science and technology, (Law, 1991a): Firstly, STS has discussed, in relative terms, the character of knowledge (epistemology) focusing on two key points: On one hand, rules of the method, epistemology, might vary as a function of social context. On the other hand, the relationship between epistemological relativism and ethical and political

⁴⁷ There are different forms and levels of participation which bring different challenges to both workers and management. For a detailed discussion see Patemann C. (1982).

⁴⁸ Nevertheless, in spite of the supportive institutional environment, few firms promoted democratisation of work programs. This was because 'The managerial control of the organisation's hierarchy makes democratisation difficult in particular because job redesign is characteristically not defined by management in terms of democracy but in terms of lower total production cost' (Bolweg, 1976: 124).

commitments was discussed. Accordingly Starr (1988), embracing epistemological relativism does not imply in giving up political and ethical commitments. From this was suggested that because knowledge is contingent, 'it could have been otherwise' (p 198)⁴⁹.

Secondly, STS has discussed the character of society. The important question was to find out what and how binds (or fractions) society. It seems to be consensus among STS scholars (Law and Callon, 1988; Latour, 1988; Hughes, 1983, Law, 1991) that society is held together by heterogeneous means, in terms of strategies and resources. That is well illustrated by Hughes' work on the development of the generation, transmission and distribution of electrical power in Western countries. He showed that the 'social glue' is not only social but also technological and that the social order is not a social order at all⁵⁰. Therefore, a pluralist set of events, processes, people and technologies, which are function on a set of past and present economics politics laws norms and traditions, constitute the ropes that *attempt* to tie society. Distribution issues are associated to the character of 'society' issues⁵¹.

In summary, STS informs that there are social choices, but those choices are constrained by social institutions (eg, established norms, laws, traditions), social relations (eg, interest, power relations) and by past technological choices (eg, established voltage in power lines, current sewage system, established human-machine interface in personal computer technology such as the MicroSoft's Windows). Then, the application of particular production concepts, like the concept of Human-centredness, might result in different outcomes, depending on the contextual conditions of the society in which it is applied. This implies that present and past economics, politics and social events play a central role. In other words, the definition of new choices is a process of negotiation driven by the social interests of participants. Therefore, the same production concepts might have different 'effects' in different contextual situations (MacKenzie and Wajcman, 1985; Bijker and Law, 1990).

⁴⁹ For a full discussion on these points see Star (1988) and Law (1991).

⁵⁰ According to Law (1991a), 'the problem of the social order can not be solved by social means alone. Structures do not simply reside in the actions of people, or in memory traces. They exist in a network of heterogeneous material arrangements. The genius of STS is to have stumbled on this, and to have taken to heart the importance of material overlaps for the "social order". It has understood that heterogeneous engineers are, as it were, out there, arranging, ordering, shaping, regulating and (to be sure) seeking to profit from such overlaps. It has understood that heterogeneous engineers - agents, whether humans or not - are constituted in the arrangement of these materials. And it has understood that such processes of ordering, such processes of working on and giving shape to the overlaps, amount, in their own precarious way, to what we call the social order' (p, 16).

⁵¹ There is third question that STS discussed, the problem of distribution. That is, the character of the division of classes or social actors. Heterogeneity of strategies and resources implies in social, technical, political, and economic division. The construction and reconstruction of overlaps among all those different dimension, allows STS to explain distribution issues. in terms of power and the understanding of the history of social (and non-social) actors.

Drawing from this brief outline, it is possible to roughly locate the STS movement in Burrell and Morgan's framework. Regarding *assumptions about the nature of society*, the STS approach can be located 'near' the 'regulation' side since attempts to explain how and why society reach some kind of accommodation. That is, STS assumes that technology, the social world, and the course of history 'should all be treated as rather messy contingencies. There is no grand plan to history - no economic, technical, psychological, or social "last instance" that drives historical change' (Bijker and Law, 1990). STS regulationism however, recognises the key role of conflict, difference and resistance in the shaping of social, scientific and technological choices. It is assumed that social change is related to power based social relations and that there is no consensus on human's goals.

Concerning *the nature of science*, the STS approach is clearly on the anti-positivistic strand (Star, 1988). That is reality is viewed as product of individuals' mind which uses labels, concepts and symbols to structure reality.

Epistemologically, STS seems to follow a relativism perspective of science and approaches it as subjective.

In respect of *assumptions about human nature*, STS uses a 'voluntarism' view, in which individuals are autonomous and free-willed (and so unpredictable), but their choices are constrained by external events. Then, consequences are equally function of a whole range of other choices of other individuals.

Methodologically, the STS follows, without doubts, an ideographic approach. Nevertheless, there seems not to exist one preferred method. Bijker and Law (1990: 12-3) noted STS writers have used different theoretical approaches. Hughes (1983) used a version of systems theory to develop his notion of large technological systems. Callon (1980) used actor-network theory, in which different components bound together in network are, at the same time, constituted and shaped by those networks. And finally, the social constructivist approach to technology explained above.

The above assumptions of the social construction of technology approach will aid to understand the landscape view that is look for in the present research.

Underlying assumptions of the Researcher

The researcher's assumptions about human beings, organisations and images of the phenomenon studied constitute another key dimension that need to be explained in order to understand the logic of research. The principal reason(s) for researching the chosen research topic and the deep reasons for using a functionalism approach, seems to be related to the experienced non satisfaction of the researcher as industrial engineer practitioner (Industrial engineering techniques were really a small part of a wider organisational world), the different perspectives of organisational life that a Master's course in administration/Organisations provided and to the wider perspective that a Doctoral dissertation offered. (ie, little is known about the dynamics of industrial organisations and its associated social, technical, organisational dimensions, let alone their joint understanding). The fact of being born and have lived in a third world nation, in which people is every day exposed to the complexity of social relations and, specially, experienced what is social inequality - without really understanding it - are additional reasons for helping to understand the researcher's 'backstage' motives for performing research in the stated form. That is, the deep goal of the researcher was to help to understand the utilisation of a more 'humanistic' production system in order to, implicitly and indirectly, contribute with the set up and diffusion of a better resource creation and distribution approach.

This background would help to understand the researcher's assumptions about the nature of social science and the nature of society. Regarding the nature of social science, ontologically this researcher approach the object of study more as a subjective matter than as an objective one. However, in the researcher view, 'reality' is a combination of these two dimensions, that really represent two extremes of a continuum. In epistemological terms, knowledge, to the researcher view, is highly subjective. This nevertheless does not imply that some 'positivist' type techniques can not be used for data collection as a complement of anti-positivist methods. Regarding human nature, the researcher view is 'voluntarism', but it is acknowledged that individuals are constrained by 'determinism' perspectives such as environmental or institutional norms and laws. Methodologically, the researcher's position is towards the ideographic approach.

Concerning assumptions about society, the researcher's view is one close to the regulation approach. However, since the regulationism view seems to be limited to explain the conflicting and contradictory relationships (with its associated power issues) between humans beings, the radical change view of society is adhered in order to understand 'disfunctions' not explained by the regulationism view.

2.4 CONCLUSIONS

The above theoretical comments lead us to acknowledge that the present research constitutes only one of the various ways in which a social phenomena can be understood. This is because of three reasons. Firstly, the highly interdependent relation that exists between methodology and the nature of scientific research. Secondly, the different approaches that science can take. Thirdly, the different assumptions about the nature of society that an specific research strand can take. Therefore, it is not intended to say that this is the correct or 'better' methodological strategy. But simply, that the present research strategy represents a contribution to understand how and why the application of alternative production orientations such as the HC model, are not strait forward. So additional research, from different social science paradigms and assumptions about society is necessary in order to round up knowledge regarding this specific matter.

The research strategy developed was eclectic. A 'broad functionalism' approach was applied in the method of collecting information in order to attempt to explain "how" questions. In the theoretical part of this dissertation, different frameworks were used at various levels of analysis in order to attempt to answer "why" questions. That allowed the better understanding of the multifaceted nature of alternative industrial organisation models (Morgan, 1990). Using the social shaping of technology perspective, constructivist views of people technology and organisation, as well as processual/configurational approaches of organisation, the changing nature of manufacturing systems, are expressed through different but complementary theoretical frameworks. Organisational studies, production engineering, industrial economics, as well as sociological accounts of management, labour and organisational reform, are the micro-frameworks that help us to understand industrial change. Work and organisational structure are the key issues that cut across the different theoretical boundaries. An important reason for adapting these different but complementary frameworks, is that because of the traditional view of organisation, production operations and labour processes, fail to capture the diversity and complexity of technical, organisational and social processes that converge in a manufacturing system.

The prominent use of 'broad functionalism' logic, therefore, does not prevent using other research logic such as a radical humanist or radical structuralism standpoint. While broad functionalism approaches were applied for the present stage of research (ie, exploration) in conjunction with anti-positivism and less regulatory views of society and science, "it could have been otherwise". That is, interpretive, radical humanist or radical structuralism

approaches for example, seem to be appropriate alternative ways for researching those topics. In fact, both ways at the same time would produce a better understanding of the research topic.

PART I

HUMAN-CENTRED MANUFACTURING SYSTEMS: THEORETICAL NOTES

CHAPTER 3

NPS IN PERSPECTIVE: IMPLICATIONS FOR THE HUMAN-CENTRED MODEL

3.1 INTRODUCTION

This Chapter examines changes that three paradigmatic production systems (the Swedish, the German and the Japanese) are currently undertaking. The goal is to assist in localising and qualifying the HC model within the dynamics of examined production systems. In section 2 a synthesis of key commonalities and differences of the examined production systems is outlined. This will inform the discussion on two developments that might result in the amalgamation of Japanese, Swedish and German production systems. Firstly, the trend towards 'Japanization' of Swedish and German production systems (section 3) and; secondly, the trend towards 'Europeanization' of the Japanese production system (section 4). The possible hybridisation process, the theme of section 5, helps to throw some light on the likely paths of hybrid forms of new production systems (NPS). Finally, the implications for the HC model are outlined in section 6.

Before proceeding to comment on those insights, it is necessary to mention common agreements in the literature concerning (cf Durand, 1993; Lane, 1989; Altmann et al, 1992; Boyer, 1993): (i) the recognition of the existence of an ongoing process of industrial restructuring in developed economies in terms of management of production and new ways of competition linked to specific sectors such as the machine tool and automobile industry where a high density of new technology exists; (ii) the present erosion of work, organizational and institutional structures deployed along tayloristic lines, does not mean that it has already been replaced by other approaches (ie, taylorist/fordist views, in general terms, continue to be the dominant approach even though it seems that they are undergoing a gradual transformation in the advanced economies' high technology sectors); (iii) little agreement exists among

observers regarding the quality, significance and extent of the restructuring process. However, commentators agree on the decisive influence of particular socio-institutional features each nation possesses to support or constrain industrial restructure (Lutz, 1992: 32-7).

3.2. ON PRODUCTION SYSTEMS

Production systems are approached from a broad view. Both micro level developments (eg, work organisation, firm strategies, human resource and industrial relations practices) and its associated macro contextual conditions (eg, labour markets, product demand rate and level of economic activity) in which production systems are inserted, constitute their two key dimensions. Next, key features of a production system, that transcend specific characteristic of each model, are explicated. In doing this the following arguments are advanced. (1) micro and macro dimensions of a production system are highly interdependent; (2) all models are intrinsically different; (3) achieved working conditions and living standards are function of the degree of workers input in both production and distribution issues; and (4) production systems are dynamically evolving.

(1) Micro and macro dimensions of a production system are highly interdependent; All production systems are constituted by two highly inter-dependent dimensions: the micro and the macro. The failure to consider simultaneously both dimensions results in a partial picture of the problem, as the sustained functioning of micro level features seems to be highly dependent on the macro contextual conditions. From the acknowledgement that different models follow different strategies and pursue different goals, it can be drawn that a condition that seems to be crucial, for the development and diffusion of a production model, is the congruence that exists between firm and macro level factors. The key explanatory arguments for the model's differences and similarities nevertheless, resides in the macro dimension.

Japanese production practices and principles, for example, were able to be implemented because they helped to achieve the government and firm goals of economic development on the one hand, and helped to raise standards of living of the general population on the other hand, within the resource limitations that Japan had. Important macro pre-requisites that contributed to the development of the Japanese production system were the minimalist State Welfare system; the strong government support for key industries developing export capacity (eg, Japan's Ministry of international trade - MITI); the weak TU bargaining power to raise claims and the existence of a trained and educated workforce. This situation leaves Japanese worker with little alternative but to accept Japanese production concepts, independent of consequences for workers (cf Ohno, 1988; Satofuka, 1992; Wilkinson and Oliver, 1989). In

the case of *Sweden*, sociotechnical principles worked well as they reflected prevailing democratic traditions, helped to solve high labour instability (high turnover and absenteeism rates), improved working conditions and sustained industrial production. Crucial macro prerequisites, such as the existence of active labour market policies to acquire further skills, a wage solidarity policy, a labour oriented government and the existence of strong and organised TUs, constitute key contextual factors that further explain the Swedish model (cf Pontusson, 1990; Meidner, 1994)⁵². In *Germany*, their particular production principles evolved as a consequence of the prevailing 'co-operative' corporate policy, the economies of scope orientation, the existence of a pool of highly skilled workers, the efficient training mechanisms and the co-determination laws that allowed worker's input for obtaining industrial efficiency (cf Chandler, 1990; Lane, 1989; Altmann et al, 1992).

(2) All production systems are intrinsically different: Despite some common characteristics that these production systems have, it is necessary to remark that to a certain extent, each production system is unique as it evolved responding to specific time, space and societal needs and consequently built particular capabilities to cope with their macro contextual conditions. Thus, paraphrasing Cole (1990), is necessary to admit that there is inevitably an element of comparing apples with oranges. But even with these problems, the comparison is useful as it helps to explain the functioning of each model within a wider macro picture. However, rather than try to determine which production system is superior, the important question should be under what conditions and in what environments different production systems perform effectively considering the outcomes for both the firm, personnel and society at large (see next section). To sustain the argument that all production systems are intrinsically different, two key issues are focused on, the different strategies followed, from conception, with each production system and; the wider long-term goals of firms and government policies which permeated the development of each production system.

Different production systems, different firm level strategies: Japanese corporations opted for an outward expansion strategy to secure long term survival. With the intention of serving overseas markets Japanese firms concentrated sharply on the mass-production of high quality and low price products and have developed the ability of reacting rapidly to customers' needs. *German* industries have focussed attention on few industrial sectors to develop economies of scope and technical excellence. They have developed the capacity to produce high performance and quality products either for mass markets or for special customers (cf Porter, 1990). *Swedish* firms like the Japanese, followed an export-oriented strategy, but opted for

⁵² In Sweden, the Social Democrat government not only set up codetermination laws but implemented a Labour economic agenda which, during the 1970s and 1980s achieved a delicate balance between economic growth, full employment and an extensive Welfare State system (Milner, 1990).

targeting the production of technically sophisticated products, competing in high quality and sophisticated design stances. This means manufacturing in small/medium-sized batches for niche and luxury markets. The above suggests that different production models therefore seem to be more adequate in serving specific markets than others. While both the German and Swedish models seem to be adequate for producing high performance customised goods (usually capital goods) for high quality markets in either relatively high volumes (Germany) or small/medium volumes (Sweden), the Japanese model is efficient for the mass production of high quality and low price consumer goods. The fact that only Japanese firms adapted, diffused and applied systematically total quality management techniques for standardising and stabilising manufacturing as well as to build quality at the source, explains why they have obtained simultaneous results in quality and price. The Japanese model nevertheless, seems to have limitations when firms try to target markets in which design and customisation are the key competitive stances (Appelbaum and Batt, 1994: 50-2).

Long-term goals of firms and government policies: The efficient production of manufactured goods is an apparent similar goal of all production systems as 'efficient' production does not only have different meanings in different settings but also different forms exist to achieve it. For example, while Japanese firms seek to increase the level of productivity as a means of obtaining economic growth and therefore long term economic stability (leaving aside firm level 'distribution' issues), the Swedish production system approached firm level productivity as part of a wider system to achieve a higher standard of living for the general population under an egalitarian approach (cf Abegglen and Stalk, 1985; Milner, 1990).

(3) Achieved working conditions and living standards are a function of the degree of workers' input in both production and distribution issues: A crucial difference between the Swedish, German and Japanese models is related to the extent to which Labour can influence 'distribution' and production 'issues'⁵³. This item is highly significant because empirical evidence (cf, Bowles and Gintis, 1995) has suggested a significant liaison between degree of labour input in production (ie, technology usage and work organization matters) and distribution (ie, rewards related matters) issues and both working conditions and the general living standard exists. The more the labour input in production and distribution issues the better the working conditions and the higher the general living standards. Considering the degree of worker input in both production and distribution issues, it is possible to distinguish two groups. On the one hand, the *Japanese* production system, in which labour has a small input in both production and distribution issues when compared to Swedish and German cases

⁵³ Distribution issues concerns the creation of conditions for stable economic growth at a sufficient rate to secure full employment. Production issues are workplace related issues such as rationalisation programs for increase productivity.

(cf Lincoln and Kalleberg, 1990)⁵⁴, seems to have lower level of both working conditions and living standards than the Swedish or German cases. The *Swedish and German cases* have higher worker input in both distribution and production issues than the Japanese case (although these nations have developed different paths). In *Germany* codetermination laws which support worker input in workplace related decision-making (production issues) seems to be more developed than a mechanism to favour worker input in distribution issues (cf Turner, 1991; Lane, 1989). Conversely, *Swedish* codetermination laws promote more worker input in distribution issues than in production issues (cf Sandberg et al, 1992). The rough outline of production and distribution issues in the three cases, together with the micro/macro view sustained, leads us to suggest that (i) as both production and distribution issues seem to be key for the improvement of both working conditions and living standards, the industrial relations factor at both micro and macro level are crucial factors for defining the performance of the production model; (ii) firm level production organisational features, that are relatively easy to replicate, constitute only a fraction of a production model and neither reflect the complexity of the process of adaptation nor its consequences over the whole society. The above points suggest that the political-economy examination of the production systems seems to be the appropriate level of analysis because it incorporates in the analysis not only cost and benefits but also distinguishes key social actors and their power holding position. In other words, any examination of production models ought to consider three essential questions. Firstly, how are gains and losses distributed? (ie, under what rationale 'gain' and 'loss' are defined by different social actors); secondly and more importantly, who decides who gains and who losses? thirdly, under what contextual conditions are worker input on both production and distribution issues more likely to be developed ?

While some answers for the first two questions have been outlined above, any answer for the third question might seem premature as NPCs are still in their formative stages. Nevertheless, based on comparative studies Turner and Auer, (1992: 4-5) have advanced four hypothesis which illustrate possible development of new hybrid models and their relation to macro institutional factors,

Where Unions are integrated in management decision-making processes through entrenched legal or bargained institutions of codetermination, unions in the current period of work reorganisation will develop proactive strategies to influence the shape of new organisation. The result will be negotiated solutions: new shopfloor organisation will take shape in a

⁵⁴ It is necessary to acknowledge that workers and TUs input in both production and distribution issues do exist (eg, workers input in small group activities through the mechanisms of decentralised responsibility and TUs input in the *shuntu* negotiation) but this is to a lesser extent when compared to the German and Swedish cases (cf Koike, 1988).

bargaining process between labour and management. One can expect in these cases that while some aspects of lean production will be adopted for efficiency purposes, other human-centred concerns that are not part of the lean system (such as longer cycle times, more autonomy for work groups, and elected group leaders) will also be incorporated. This pattern can be seen in Sweden as is developing in Germany.

Where unions have long established arm's-length relations with employers and no formal rights in management decision-making, unions will face a choice between collaboration and opposition but will be unable to play a proactive role in influencing the shape of new work organisation (at least until the arm's-length relation is substantially changed). Management will push for the implementation of its own teams concepts (heavily influenced by Japanese/lean models). The transition to new work organisation will be rocky as management encounters a patchwork pattern of acceptance and rejection within the workforce, as the US experience indicates.

The specific form and implementation of new work organisation is linked not only to industrial relations but to other factors such as national and local labour market conditions. The drive to implement human-centred forms of work organisation is stronger in tight labour markets, where competition for labour is based not only on wages but on the quality of jobs. In loose, low-skilled labour markets, new forms of work organisation are less necessary to attract labour, leaving room either for lower skilled, traditional work organisation or for lean production.

There is a link between labour-market incentives for work reorganisation and the national (and local) vocational training system. If such a system produces high skills as a 'public good', the spread of human-centred work organisation based on high skills content becomes more probable. Contemporary Swedish and German experience provide evidence for this claim.

(4) Production systems are evolving dynamically: Because macro contextual conditions are continually changing the firm level bundle of features is also, formally or informally, slowly or rapidly, evolving to be congruent with current macro conditions. The case of *Sweden* is representative. Because the newly liberal-oriented government set up (questionable) economic policies for improving industrial performance (eg, 20 % devaluation of the currency), indirectly allowed decentralised negotiations between firms and TUs and scrapped the full employment policy, some key features of the Swedish production model no longer can stand. For example, wage solidarity policies are difficult to implement as outcomes of local negotiations are highly heterogeneous; the promotion of active internal labour markets is limited by the lower investment that firms do for (re)training their own personnel as existing unemployment allow personnel to be hired straight from the labour market (Berggren, 1994a; Meidner, 1994, 1997). In the case of *Japan* contextual conditions of the 1990s are also pressing the adaptation of some 'pillars' of the Japanese model. In the automobile industry for example, the rise in the education level of young workers allied to their awareness of working conditions in other nations, make it difficult for firms to hire young skilled personnel. With the Japanese economy in recession, the stagnation of firms' market share hinders the implementation of active internal labour markets as well as undermining some key institutions that helped to build worker commitment and loyalty to the firm: seniority wages, group performance evaluation (for pay and promotion) and external JIT, for example, are starting to

be limited in order to enable the 'economic survival' of the firm (Cusumano, 1994; Berggren, 1995). In *Germany*, the Japanese 'threat' together European market unification and large investments needed by former East Germany to catch up competitiveness, are pushing Germany to rethink its production model. It has become imperative to catch up with Japanese productivity levels. Therefore, within the codetermination frame, Japanese style organisational innovations have been started to be implemented⁵⁵. Different forms of Japanese style workgroup, selected JIT and Kaizen techniques are being tested. The cost-target approach for example is being introduced to overcome problems emerged by over-engineered practices; the use of simultaneous engineering and the creation of Japanese type network of suppliers, accompanied by vertical de-integration⁵⁶; and a diverse mechanism to increase workers' accountability for outcomes are already being implemented (Jurgens, 1993a). A brief outline on how these new developments towards hybrid forms of NPSs are being deployed in Sweden, Germany and Japan is outlined in the next sections⁵⁷.

3.3 TOWARDS THE JAPANIZATION OF SWEDISH AND GERMAN PRODUCTION SYSTEMS ?

While there is increasing evidence that Swedish and German companies are applying Japanese type production practices and concepts, there is not a clear picture on how this process occurs and which are the associated problems this move might bring. In this section latest developments regarding new deployments in NPSs are reviewed in order to contribute to their understanding.

The adaptation of Japanese concepts by Swedish and German firms: Empirical research (cf, Auer, 1994, Kumazawa, 1992; Cook, 1993; Enderle, 1997) has suggested that a wide spectrum of different production practices have been occurring for a while, as a result of piece-meal borrowing from different production system. Techniques and concepts are introduced differently in different work contexts. Because firms possess different availability of

⁵⁵ Womack, Jones and Roos' book The machine that Changed the World, seems to have had a large influence in these developments as it was widely diffused among German industrialists and managers (Cooke quoted by Auer, 1994).

⁵⁶ This is one aspect which is increasingly being adopted from the Japanese model. Auer (1994) observed an increase in the percentage of outsourced parts/components and the reduction of 'first tier' suppliers in selected German industries.

⁵⁷ It should be noted nevertheless, that the trend to test different production concepts is not limited to Japan, Germany or Sweden. For the Dutch developments see Dankbaar, (1995) and Benders and Dankbaar, (1997). For the Belgium case see Huys and Van Hootegen (1995), and for experiences in Italy see Camuffo and Volpato (1997).

skilled workers, both workers and TUs react differently; external labour markets are different in different regions and nations, so the pressure on workers to accept Japanese type working conditions is different. On the one hand, there is Mercedes Benz's plant in Rastatt for example, Swedish Uddevalla concepts were blended with German production concepts supplemented by a touch of Japanese Kaizen practices. Then, the traditional assembly line was abolished in around half the operations and there is a universal attempt to achieve integral, long-cyclic work content (work content of 1-2 hours in stationary areas and 15-45 minutes on the assembly line). On the other hand, the 'Japanisation' of German plants is occurring but in peripheral sites only, in which codetermination laws do not apply or are just beginning to be implemented. That is in both former East German sites and overseas. To operate this strategy, different approaches are followed. For example, a joint venture with Toyota for the production of vans in its Hanover plant; changes towards the implementation of JIT and kaizen techniques in its engine plant at Salzgitter; new Japanese type work practices at Martorrel and Mosel (in the former East Germany) and the total 'japanisation' of GM Europe's Eisenach plant⁵⁸ (Jurgens, 1992, 1993a, Auer, 1994). The heterogenous trend for adapting Japanese type work and management strategies in Germany brings massive problems associated with the high heterogeneity of forms of adaptation.

Problems of adopting Japanese concepts in German and Swedish firms: At the level of the firm, the following problematic issues are emerging (Auer, 1994; Kumazawa, 1992; Cook, 1993): (i) While management has clear goals in adopting Japanese techniques (ie, to achieve efficient production), workers and TUs have to develop strategies in such a way as to not lose acquired rights (eg, paid vacations, limited working hours, overtime payment, sick leave and so forth); (ii) because the Lean concept is vague, many 'Japanese' concepts can be vested as 'European' because of their similarity: multiskilling, group work and some kaizen techniques can be part of both models; (iii) the German institution of skilled (semi) autonomous workers, is not compatible with some Japanese practices. For example, Japanese on-the-job training programs for multiskills departs from the German 'humanisation' of work policies and vocational training mechanisms⁵⁹; (iv) employee participation (input) in decision-making exists but it is harnessed to promote further elimination of waste and defects (only); because no 'idle time' is allowed to workers and relief workers do not exist, work intensity is high; (v) the existence of independent TUs and codetermination laws is highly incongruent

⁵⁸ At the Eisenach plant, NUMMI and CAMI were models for the design of the plant. So the (Japanese type) team principles were widespread; the assembly line was conventional, cycle-time were short and the kanban system was introduced. The workforce however, seems to have higher qualifications than of Japanese plants in Japan and US as all of them possess the Facharbeiter training (Jurgens, 1993a).

⁵⁹ 'in fact, the so called 'multi-skilled' versatility required of an employee is frequently no more than an adaptive capability to perform a number of simplified operations as swiftly as possible in a limited amount of time' (Kumazawa, 1992: 111)

with the Japanese model as it does not enable management unilateral decisions in labour deployment and work organisation (eg, work load, job definition, manning level, and transfer of workers) as well as in setting the rules to define the variable component (based on individual performance evaluation) of wage; (vi) A similar picture occurs in small and medium firms. As a result of outsourcing policies, small and medium firms would eventually have raising demand, but this will occur only if they comply with the cost-cutting and quality standards of customers. Additionally, as risk-sharing and fair payment policies are not yet developed, the actual relationship between large and subcontracted firms are more like master-slave relationships than partnerships⁶⁰.

At macro institutional level, because significant institutional and socio-cultural differences exists between German and Japanese Industrial relations systems, the application of Japanese type practices either by German firms or by Japanese companies in Germany, is not expected to be without problems⁶¹. The following problems have been raised (Deutschmann, 1992; Nomura, 1992, Sauer, 1993): (i) the set up of a 'competitive' (Japanese style) network of suppliers in Germany involves ambiguous consequences: A falling number of first-tier suppliers, establishing a hierarchically organised pyramid, job cuts in parent firms as whole components can be designed/manufactured by suppliers; further skill polarisation in suppliers; and stress caused by high workload, close deadlines and flexible adjustment to needs of customers, changed status of employment (towards low-waged fix-term and temporary employment); and changed structure of working time (eg, more shift work and overtime) on the one hand. On the other hand, as parents firms reduce their in-house design and/or production activities, the level and status of employees is stabilised; as demand might eventually increase, the expansion of capacity contributed to growth; the realisation of more design and manufacturing activities, with its associated quality assurance and logistic areas, might lead to the further acquisition of skills; (ii) the existence of closed internal labour is basic pre-condition to developing and applying (Japanese style) complex appraisal and wage systems, useful for 'managing employees individually and thoroughly'. Again, closed internal labour markets are not common practice in Germany; (iii) the Japanese model assumes the existence of an employment security mechanism that works as trade off for workers' acceptance of internal adjustment, industrial peace and identification with corporate strategies and employment. Nevertheless, this mechanism seems to be suitable for the Japanese context

⁶⁰ Berggren et al (1992) pointed out similar findings at US 'transplants': no regulation of work intensity; excessive demands for overtime work, intense pace and repetitiveness, long working hours leading to significant health problems; and stringent factory regulation (eg, mandatory uniforms, exacting attendance demands, detailed codes of conduct and discipline, elimination of all personal attributes).

⁶¹ Sociocultural conflicts, for example, might arise between work councils and Japanese management in handling labour deployment matters, as the way they handled those matters is totally different (cf Deutschmann, 1992).

in which low unemployment levels occur and the employment stability of the whole system is based on the low employment stability of subcontracted firms. It follows that for Western firms to successfully adopt Japanese style concepts employment security mechanism does need to exit. How will those be developed in nations, in which two digit unemployment level occurs and the unemployed are, usually, part of long established Welfare State mechanism?; (iv) an important critique to the implementation of the Japanese model in western settings is that it challenges the whole economic system in which Western firms evolved (Auer, 1994). Because Japanese production involves 'lean' workforce (ie, less number of workers per produced unit) there seem to be a embedded component which favour further unemployment levels. This becomes an structural problem when Japanese production rationalisation practices are applied in all economic sectors and are combined with job saving new technology and job cutting reengineering concepts⁶². While it can be argued that this is not the only time unemployment has occurred (eg, the case of the introduction of new technologies), this time special conditions seem to exist that raise worrisome questions concerning not only the future of work but of the whole economic system, as less full time well paid workers means market reduction and less taxes to support the increasingly larger Welfare State system.

'And this time things could develop differently, as the business cycle downturn comes together with organisational rationalisation not only in one sector of the economy but in all sectors simultaneously Lean production in Europe means after all cost reduction and cost reduction means lean employment (slack concerning mostly overmanning or redundancies) and this seems still to be a fundamental difference with Japanese, which has obviously the employment levels compatible with lean forms of production, although Japan - more so because of falling demand - faces now problems on the employment side' (Auer, 1994: 26-8).

In summary, because above development are still occurring, there is no clear answer to those questions. What is clear however, is the view that the resolution of the above challenges is a function of the general state of industrial relations at macro level. That is, while management choice is important, the sustainable implementation of Japanese type techniques seems to be closely linked to TUs bargaining power (to minimise potential negative outcomes) and government policy trends (roughly, either pro labour or pro liberal types). In Germany for example strong TUs, codetermination laws are favouring not only a slow introduction of Japanese production techniques but also their 'adaptation' to German conditions⁶³. German

⁶² A McKinsey report forecast that 'the removal of trade barriers can be expected to lead to millions of pounds' worth of lost sales for European motor manufacturers, accompanied by the loss of more than 100,000 jobs, as a result of the inflow of Japanese products and capital' (Neumann, 1993). Jurgens (1993a) has pointed out that VW and Mercedes-Benz, for example, have already reduced their personnel by around 15 % within the framework of the introduction of 'Lean' production concepts .

⁶³ In 1992 the German employers' Association for the Metal Industries (Arbeitgeberverband Gesamtmetall) issued a document, which would be shared by many unionists, with 12 recommendations regarding the use of lean production concepts: (i) design work content and work organisation in such a way that they increase the work motivation of your employees; (ii) use the benefits of teamwork; (iii) integrate the tasks of planning and executing work, speed up product development through 'simultaneous engineering'; (iv)

TUs have proposed a 'productivity pact' supporting the introduction of Japanese production techniques in exchange for expanding the co-determination rights to personnel staffing levels and thus performance standards in the white collar area (Jurgens, 1993a). Nevertheless, while Government, industrialists and TUs are discussing these problematic issues, the emerging picture, from a labour perspective, reveals a dark view since there seems to be an increasing work intensity and the declining volume of jobs.

3.4 TOWARDS THE EUROPEANIZATION OF JAPANESE PRODUCTION SYSTEM ?

For different reasons, the Japanese model seems to be changing too. Japan's growing surplus of in foreign trade, domestic socio-economic problems, increased awareness of the youth and general population regarding the use of free time for leisure and its associated labour shortage implications, declining profits⁶⁴ together with international pressure to have access to the protected Japanese domestic market are calling for the structural adaptation of the Japanese economy. This seems to constitute a key factor for Japan being entitled to have access to a large market (eg, NAFTA and EC agreements) (Demes, 1992; Nomura 1992b). Key social actors (industrialist, TUs, and government) have already started to implement new policies to adapt both production issues (eg, policies aiming for better working conditions) and distribution issues (aiming for the improvement of job conditions such as shorter working hours, longer holidays, better wages) to the new contextual conditions⁶⁵.

Several cases of the application of Swedish style *production organisation concepts* have already been registered in Japan, both in mass and non-mass production (cf, Gronning, 1995; Shimizu, 1995). At Toyota for example, the concept of 'autonomous Complete Process', was

maintain and increase the qualifications of your employees; (v) increase the quality of the work; make work time flexible; (vi) design a system of remuneration which supports performance as well as co-operation; (vii) design work to promote the health of your employees; (viii) keep your employees informed and let them participate; (ix) co-operate with your work councils on the basis of trust; (x) practice your leadership (Jurgens, 1993a:10).

⁶⁴ Despite the Toyota production systems being said to be a production system suitable for manufacturing a wide variety of models in small batches, declining profits (the ratio of operating profit to sales fell from 7,5 % in 1990 to 1,3 % in 1992) resulted due to the increase of models and its associated increased cost in R & D expenditures, high cost of frequent model replacement, line expansion and depreciation reserves (Nomura, 1992b; Cusumano, 1994). It should be noted however, that an alternative way to overcome this problem is to reduce the number of new models and its variations, something that goes against the 'traditional' Japanese model.

⁶⁵ In order to cope problems with increasing personnel instability, a forced automation of production processes is simultaneously occurring (Jurgens, 1993).

implemented. It involved the diminution of fragmentation of tasks to partially recover the contextual meaning in assembly, but without eliminating the assembly line. In Toyota's new Tahara plant for example, work organisation and layout are designed to reduce the intensity of work, to remove workers partially from the line and to establish better working conditions (Japan Times, quoted by Newmann, 1993). Instead of the traditional assembly line, 8 mini lines with 5-minute buffers were set up in order to make each section, as far as possible, self-completing. At Toyota's Kyushu plant, besides the similarity that the assembly shop has with Swedish Kalmar concepts, the main innovations were introduced in the reward system, working hours, management style and suggestion schemes. At Kyushu, there was a 'continuous shift' system (eg, first shift 06:00-14:50 and second shift 15:05-23:55) implemented in order to minimise forced overtime; the new suggestion system was not interested in the number of suggestions per worker per year; There were not targets; the assembly line was divided in 11 mini-lines with 5-car buffers at each mini-line; each line was the responsibility of a production team. In the Honda plant at Takanezawa and the Daihatsu plant in Osaka, Uddevalla type work organisation was applied: assembly work without assembly lines in which skilled workers work with long cycle times and have a wide range of deployment possibilities. In other assembly industries such as video camera, photocopy machines, portable telephone, air conditioner and so on, assembly work with a team and without belt conveyer have now been introduced (Berggren, 1995: 76-8; Nohara, 1997). It should be noted that above Swedish style organisational innovations are in total discrepancy with some of the central Ohno's principles: as buffers are introduced and work partially is decoupled from the line (using mini-line concepts), a lesser degree of interdependence between production tasks occurs. Those deployments call for new forms of production and worker control as Kanban and JIT techniques are more suitable for highly inter-dependent tasks than for decoupled tasks. Therefore, it was expected Japanese managerial style would also evolve.

Government policies aiming to increase employees' share in national wealth in order to improve living conditions have already been outlined. The 1992 'The 5-year Economic Plan: Sharing a better Quality of life Around the Globe', plan was published by the Japanese government. This plan proposed (i) reducing working hours in the long term; (ii) increase the minimum overtime wages; set up of new shift models to reduce required overtime⁶⁶ including non-paid overtime; reduce the school week to 5 days; enlarging the cycle of some products

⁶⁶ Demes (1992) pointed out that between the day and night shift there is a gap of several hours that is usually filled with overtime work.

(especially electronics) as this is linked with increasing demand for overtime work and is raising criticisms as it supports the 'wasteful' society trend⁶⁷(Demes, 1992, Nomura, 1992b).

A further step towards the implementation of government policies occurred in May of 1995, when the *Japan Federation of Employers' Association (Nikkeiren)* proposed a new type of Japanese management in the document 'Japanese Management in the New Era - its orientation to be challenged and its measures' (Koyama, 1997). Theoretically, the Nikkeiren document explicitly points out that the traditional 'three pillars' of Japanese management (ie, lifetime employment, seniority-based wages and the co-operative relations between labour and management) will no longer be used. Instead, two basic ideas ought to be applied. 'Human-centred management' and 'management with a long-term vision'. According to Nikkeiren, these two ideas produce 'stability of employment, meaningful lives for workers, improvement of abilities, teamwork and good wage relations'. Despite the rethoric used, the final goal of Nikkeiren seems to be the improvement of competitiveness through the flexibilization of employment and Human resource policies. The framework for the flexibilization of employment relations involves the classification of employees in three groups, each group would be employed under different contractual conditions. The first group called 'long-term accumulated ability' have similar job and working conditions as in the former 3-pillar system. That is personnel is employed on a permanent basis and embraces managers, executives and technical staff; wages are based on the evaluation of individual job-ability accompanied by fixed rate and scale bonuses; promotions are based on job classifications and the retirement allowance and pension system is based on a points system. The second group, 'higher professional ability group', is directed to regulate job and employment conditions of special department staff (eg, R & D, planning, sales); the employment contract is of a limited period; wages, bonus and promotions are a function of results achieved; there is no retirement allowance or pension system. The key departure from the traditional Japanese model, for these two first groups was the introduction of some type of 'time autonomy' for white-collar workers and non-routine jobs as a counter-part measure for the new results-oriented wage and promotion systems. The third group, is directed to regulate employment and job conditions of the peripheral workforce. That is, personnel performing general duties, some technical and selling jobs are contracted under fixed time periods; wages are defined by time rates and job evaluation; bonuses are fixed and neither a retirement allowance or pensions nor promotions exist.

The above policy recommendations represent an important shift (or evolution) in the constitution of the Japanese model. The results-oriented wage system, the 'time autonomy'

⁶⁷ The increase in the cycle of products is supported not only by TUs but also by the MITI and Ministry of labour .

idea and the flexibilization of employment relations points out a convergence of employment and wage relations with the Western approach. It should be noted that for Nikkeiren, the flexibilization of the employment system and the human resource management does not seem to be contradictory to their two new basic principles of human-centred and long-term management. While it seems to be clear that the traditional '3-pillars' of the Japanese model are being scrapped, it is not clear what exactly they mean by 'human-centred and long-term management' and what are the implications for both workers and firms. On the one hand, the flexibilization of employment conditions without doubt will allow firms leeway to deal with market fluctuations as the third group of the Nikkeiren document represents the legalisation of illegal employment (foreign, women and older workers) and its associated lower wage, job and working conditions. On the other hand, it is still too early to evaluate if those new measures will allow the firm to have highly motivated skilled personnel 'on call', as the institution of internal labour markets will be relaxed and external labour markets are not enterprise controlled.

The 'new' system involves, for workers, the personalization of wage relations, further job intensity (for groups and individuals) and thirdly, the further polarization and instability of employment (for groups 2 and 3)⁶⁸. This means (i) the formalization of less egalitarian policies (as the 3 groups have different working and job conditions); (ii) the legalisation of lower working and job conditions for the peripheral workforce (group 3). This implies in the perpetuation of those social conditions; (iii) the 'flexibility' of external labour markets will promote high work instability for highly skilled personnel (group 2). In short, the Nikkeiren approach for adapting the Japanese model to new contextual conditions, seems to represent, in the name of economic goals, a step backward for working and job conditions, which in societal terms means higher social inequality. While the above direction seems to converge with Western style industrial relations, it should be noted that state welfare mechanisms in Western nations are fairly well developed (minimum living standards are assured to workers), something that does not occur in Japan.

In spite of the controversy that the above development may generate, Jurgens (1993b) argued that the key question is whether or not the new type of Japanese wage and employment conditions will be able to sustain workers' loyalty, morale and consent on the one hand, and on the other hand, to what extent the new Japanese model will be able to adapt European

⁶⁸ Individual assessment that increases competition among groups brings new problems for maintaining the 'family atmosphere' that Toyota pursues and that helps to create the corporate culture, a basic element of the Japanese system. This involves the pursuit of a large number of 'human relations' activities which occur off-duty. Despite those human relations activities not being compulsory, 'employees think that the personnel assessment will go down when he refuses to participate in the activities. Because of these activities the supervisors and the managers hardly have private time on holidays' (Nomura, 1992b: 15)

Humanisation of work approaches to simultaneously make work attractive, sustain increasing factory automation, and provide intensive training for automated equipment maintenance areas. The answer seems to be function of the capacity of the new system to deliver improved working and job conditions.

The (representative) automobile industry for example, is already implementing measures aiming for both the *improvement of working conditions* and the implementation of the above mentioned new job *and employment conditions*. For example, Mazda in Hofu, Nissan and Toyota in Kyushu new plants are introducing measures and concepts directly linked to the improvement of working conditions; ergonomic aspects for example are being considered for the first time, noise reduction devices, longer cycle times, introduction of buffers and storage units as well as the improvement of canteens and sports facilities are some common measures introduced (Demes, 1992). At Toyota, the concept of 'necessary' waste to improve human conditions is being introduced (Nomura, 1992b) and this involves the use of buffer stocks and the review of the JIT delivery system, one of the 'pillars' of the Japanese model⁶⁹. Together with those changes, Toyota has started to change its wage system and new employment practices (such as those described above) since 1990⁷⁰. Therefore, it does not seem to be a coincidence that those improvements are very similar to those discussed and implemented in Sweden and Germany in the 1980s under the 'Humanisation of work' program, as the labour market problem that Japan is facing in the mid 1990s is similar to the Swedish and German situation in the 1980s. Thus, while those changes in the Japanese model seem to depart from traditional Japanese concepts, they, as Benders (1996) noted, look more evolutionary than revolutionary.

⁶⁹ Because the traditional JIT delivery system (that means 'frequent delivery of parts in small quantity') decreases transportation efficiency, the 1991 document 'Distribution strategies toward the 21st Century' clearly asked for a review of this system: 'Viewed from the aspect of the just-in-time service which features the frequent delivery of small lots, the service system tends to cause inefficiency in transportation because the volume of goods delivered depends entirely on the needs of production and sales people, not on those of distributors. Viewed from the other aspect of the service system which features shorter delivery lead-time and strictly appointed delivery time, the system involves negative factors in terms of efficient and labour-saving delivery. Waiting time on the part of distributors increases to keep up with production and sales schedules. Also, the driving time needed increases because of difficulty in observing the appointed time, stemming from worsening traffic congestion. These factors in turn increase non-productive working time' (quoted in Kameyama, 1991).

⁷⁰ At Toyota for example, the concepts of age and skill related payment were introduced in 1990 and, on the other hand the proportion of productivity wage was reduced from 60 % to 40 %. The 'Professional contractor' (PC) system has been implemented since 1994. The PC system, according to Tanada (quoted by Komaya, 1997), aims to make practical use of highly skilled labour, which was not formed by the corporate culture of the firm, who obtain not only higher wages (separated from regular employees) but also can work freely without working time restrictions. In February 1997 for example 5 people were employed under this system: 2 car designers; 1 researcher in biotechnology; 1 researcher for the development of batteries for electrical vehicles; and 1 for integrated transport systems (Koyama, 1997).

In summary, the above suggests that significant changes are occurring not only in the European Swedish and German models, but also in the Japanese model. On the one hand, Swedish and Germans are introducing Japanese type production techniques in order to match Japanese levels of productivity. On the other hand, there is little doubt that the 'new' Japanese model is emerging in order to cope with new contextual conditions. Japanese Government, TUs and employers are favouring changes not only in production techniques but also in the human resource concepts in order to achieve an equilibrium between the firm industrial relations and its context. In the next section the possible hybridisation or new synthesis of Japanese and European production models that seems to be underway⁷¹ is outlined.

3.5 POST-LEAN PRODUCTION: JAPANESE PRODUCTION ORGANISATION CONCEPTS WITH EUROPEAN "HUMANISATION OF WORK" SPIRIT ?

So far, it was suggested that both the Japanese and European (Swedish and German) production models are, as presented today, unable to cope with contextual conditions. Then the argument developed here is that a synthesis of both models is being shaped by key social actors. The new synthesis would involve the adaptation of some Japanese production organisation techniques that match advanced European industrial relations practices. This process, seems to be, from the rational perspective, adequate as Swedish and German contributions in work organisation and job design have occurred in areas in which Japanese management did not focus⁷². This wave of change paradoxically has an European 'Humanisation of work' flavour. While it is too early to evaluate how this process is being developed, in this section, a possible hybridisation or new synthesis of Japanese and European model is discussed.

There are features in both models which can be amalgamated and features in which combination is difficult due to the contradictory characteristics of the concepts involved (Berggren, 1992a). On the one hand, elements of the two models which are feasible for

⁷¹ Appelbaum and Batt (1994) for example reviewing more than 200 US case studies concluded that since the mid-1980s specific practices from different model are being borrowed and implemented in a piecemeal way.

⁷² Work reform in U.S. firms, for example, were characterised by their borrowing of particular practices or pieces of the Japanese, Swedish and German models. Among the large variety of hybrid forms of work reform, two strands were differentiated. The American version of lean production (emphasising the use of top management-driven quality systems) and a more decentralised system called 'American team production' which combines the principles of Swedish sociotechnical principles and self-directed work with those of quality engineering. Converging with the arguments advanced earlier, Appelbaum and Batt (1994: 125) pointed out that the key difference between those two hybrid models, center mainly on differences in human resource and industrial relations policies rather than on differences in product markets, technology or organisational strategies .

combination are: (i) the use of Japanese product development concepts and techniques (eg, QFD) would greatly improve the Swedish design process; (ii) the use of Japanese type relations with suppliers; (iii) the adaptation of some elements of Japanese standardisation of procedures to the long-cycle Swedish way of work, would benefit the latter by creating order and a more systematic approach to developing standards for critical tasks as well as improved tool and QC procedures for example.

On the other hand there are 2 features in each model which seems to be difficult to fit. Firstly, the current Japanese approach to waste, that involves low buffers among units and results in high task interdependence. The recognition of the need for 'socially' acceptable waste, as suggested by Nomura (1992b), will make it feasible to adapt some Swedish or German work organisation principles, which are based on the de-coupling of workers from the production line in order to provide leeway for problem-solving activities. Secondly, there is a central contradiction in both production systems which is based on the concept of flexibility. Flexibility can be approached (as the Japanese model does) just in pure economic terms, demanding employees achieve numerical goals; or flexibility can be approached considering both economic outcomes and human needs.

Features of the Swedish model that might help to improve the Japanese model are (Berggren (1992a: 253-4) :

- ♦ The integration of subdivided tasks and monotonous mass-production work to more dignified and holistic tasks. Swedish experience showed that there are technically feasible alternatives, compatible with varied market demands and socially sound outcomes;
- ♦ The broad development of the physical work environment, especially the ergonomic aspects of manual workplaces in order to minimise repetitive strain injury;
- ♦ The efforts to make work systems less rigidly coupled and more adaptable to meeting diverse human needs;
- ♦ The high degree of involvement of Unions in decision making and planning processes as independent partners with legitimate interest on their own.

The process of borrowing, testing and adaptation of specific production concepts within different production systems and under different contextual conditions is currently occurring in the automobile industry world wide (cf, Camuffo and Volpato, 1997; Freyssenet, 1995; Huys and Van Hootegeem, 1997; Benders and Dankbaar, 1997).

At the firm level, the combination of features from the different models has focused on aspects related to work organisation and production design. Nevertheless, because different plants possess different degrees of automation, work organisation patterns, management styles background, serve to different markets, and are inserted into different contextual conditions⁷³, a wide variety of hybrid models are feasible to emerge. Fujimoto et al (1997) have interpreted those developments as a simultaneous process of convergence and mutual learning at the level of techniques, management practices and organizational forms. Convergence regarding the spread of specific JIT techniques such as teamwork, problem-solving activities and product based layouts. Mutual learning occurs as a result of the process of borrowing among the main production systems. Nevertheless, should be clear that while some convergence of rationalisation is occurring, there is a divergence on interest representation and wider industrial relations (Altmann, 1992). This process is supported by the higher mobility of capital that the globalisation of the economies bring what, in turn, promotes the opening of European nations plants in Eastern and American nations as well as the set up of Japanese and Korean plants in Europe and (South) America.

Because there seems to be a transitional time, preliminary conclusions only can be drawn⁷⁴. Firstly, it can be suggested that more than the 'survival' of one production system, the late 1990s is witnessing an 'evolutionary hybridisation' process. In this process different firms (usually automobile producers) borrow particular concepts from different production systems in a piece-meal fashion. This process nevertheless, seems to be strongly constrained by national macro contextual conditions such as labour and product markets, the wider industrial relations system, quality of available manpower skills and level of economic activity, among others.

Second, the wide diversity of resulting hybrid models would be complementary since one firm usually posses different plants serving different markets and so they might have different production design orientations.

While many questions regarding likely patterns of development, technical outcomes, social issues and its associated macro institutional requirements continue to emerge, at this point is necessary to go back to the initial research question and discuss how these developments in new production systems might influence the development of the HC model. This is attempted in the next section.

⁷³ The successful implementation of new hybrid models seems to be function of management choice, the type of industrial relations system and other macro institutional factors (eg, educational and vocational training systems) in which they perform (cf, Cole, 1990).

⁷⁴ These preliminary insights converge with the findings of Jurgens et al (1997).

3.6 NEW PRODUCTION SYSTEMS IN PERSPECTIVE: IMPLICATIONS FOR THE HUMAN-CENTRED MODEL

Drawing from insights of the Swedish, German and Japanese production systems, next, key aspects of the HC model are outlined.

- ♦ The HC model has 2 dimensions: the firm level (micro) and (macro) contextual. Macro contextual conditions explain, in significant extent, developments at the level of the firm.
- ♦ The HC model acknowledges its context-dependent nature. Then, while the HC model represents a general design orientation, it recognises that different nations with different institutions and resources would adapt differently the main guidelines of the HC model.
- ♦ Because of the strong dependence on macro institutional factors, the implementation of HC work and organisational principles does not seem to be free of problems. This involves a dynamic model flexible enough to be adopted to real shopfloor and macro contextual conditions. Therefore, it should not be expected a rigid and strait application of HC guidelines, but a selective, step-by-step implementation of HC principles.
- ♦ The HC model recognises its role as a 'model' from which can be learned but should not be copied; leaves space open for the adaptation process; informs its strengths and weaknesses, both technical and social;
- ♦ The HC model recognises the importance of not only promoting the increase of factory productivity but also considers the wider implications that specific form of work organisation brings for key social actors. Therefore, the HC model has as a designed feature, both the improvement of working conditions and the support of worker's input in production and distribution issues.
- ♦ Because the path to be taken by the HC model during the probable hybridisation process seems to be highly dependent on the specific time, space and societal contextual needs, a wide variety of HC forms is expected.
- ♦ The HC model recognises that specific features of a production system constitutes a fraction of a whole national system of innovation only. The production system is only part

of a wide and complex network of institutions which are key for supporting socio-economic development.

- ♦ The evolution of both the Swedish and the German production models and its possible hybridisation with the Japanese model, suggests an evolution of the HC model and a parallel 'learning' from the Japanese approach. This means that, as above mentioned, some positive features of the Japanese model might be incorporated to the HC model⁷⁵. Nevertheless, rest to be seen how Japanese type production techniques can be adapted to the HC model as they possess significant philosophical differences. That is, the key question at this stage is how to 'learn' from the Japanese without reaching the heart of the HC model: the achievement of higher industrial competitiveness, working conditions and living standards via the promotion of workers input in both production and distribution issues.

Thus, considering the flexible and non-deterministic nature of the HC model and recognising its subordination to macro contextual conditions, in the next Chapters of this theoretical part, a firm level conceptualisation is made and a macro level view is developed focusing on the Brazilian setting.

⁷⁵ Whether or not this is happening is an open question waiting for empirical research.

CHAPTER 4

HCMS: A FIRM LEVEL CONCEPTUALISATION

4.1 INTRODUCTION:

This chapter examines the Human-Centred Manufacturing System (HCMS), its components and dimensions as well as their relations by locating it as a particular style of a generic manufacturing system model. The chapter takes a comprehensive view of the processes inside and around manufacturing as well as examining its associated socio-political issues. It proposes what is described as a configurational/processual approach that helps to understand and locate the key functions of a manufacturing system. Because the HC approach is new and is still an ongoing process, its theoretical foundations are not a cohesive finished package. There is little in-depth understanding about the nature and functioning at manufacturing systems, due to their inherent complexity. The implementation dimension especially, is the least researched, even though it is important. Current HC theoretical developments are rather dispersed as different research programs focus upon different issues. In this present chapter then, rather than attempting to thoroughly review all existing HC literature, the organisational component is emphasised as this was detected as a gap in the literature. This does not involve a down playing other important aspects of the HC concept.

Since F.W. Taylor's Scientific Management and Joan Woodward's Industrial Organisation, typical views of production systems tend to stress, either the technical or the organisational side, or the social side of production systems, leaving the examination of the productive process, as a whole, aside. In order to overcome partial and mechanistic views of manufacturing systems, an alternative way to explain manufacturing systems functioning is proposed in the present study. The HCMS concept developed here, builds on two sets of literature. First, the social construction of technology and soft-determinism views of technology and organisations. Second, the Manufacturing Engineering Systems (MES) concept. The 2 sets of literature are drawn on in order to develop a framework for conceptualising the nature and dynamics of HCMS.

The theoretical framework proposed has 4 parts. The first two parts deal with the design and principles of technological and organisational components of HCMS. The last two parts refer to the implementation and configuration of the technology and organisational components of HCMS. In the conclusion, it is argued that the HCMS concept is better approached, recognising the importance of strategic congruence between HCMS and the firm's environment.

In the next section then, three complementary concepts for reflecting the dynamics of production systems are elaborated. These are, the constructivist views of technology, technological and organisational configurations, and processual approaches to organisational change. Section 3 presents a framework developed to understand the dynamics of the key constituencies of a HCMS. It combines the idea of MES and organisational configurations. The remaining sections further explain key components and stages of HCMS. The design and principles of technology and organisational components of HCMS are outlined in section 4. Implementation and configuration issues relating to technology and organisation are developed in section 5. Furthermore, a model aimed at assisting with the implementation and configuration of a production system in HC terms is developed in this section. Section 6 further extends key issues of the process of HC design and implementation of HCMS. Finally, section 7 develops the importance of strategic congruence between HCMS and the firm's environment in order to better explain the dynamics of HCMS.

4.2 CONSTRUCTIVIST VIEWS OF PEOPLE, TECHNOLOGY AND ORGANISATION

Constructivist views of technology, approaches technology design and application as the outcome of a series of actions made by people (eg designers, implementors, financiers, vendors and users among others), who directly or indirectly, consciously or unconsciously make decisions in order to develop a specific technology. Intentions, implicit and explicit goals, ways of thinking, as well as assumptions concerning the role of humans in the use or application of specific technology, are all embedded in the hardware, software and knowledge produced (MacKenzie and Wajcman, 1985; Molle and Elliot, 1987).

Decisions and actions to develop and or modify technology may occur in different stages of technology development, and therefore, in different time positions. Usually, however, technical artefacts are designed following the prevailing socio-institutional norms, attitudes and 'views of world' of a particular society where it occurs (cf Belt and Rip, 1984; Noble, 1984; Dosi, 1984; Clark, 1987).

Within a constructivist framework of technology, a soft-determinism is adopted. Soft-determinism arguments advance a middle way position between technological determinism and social determinism. That is, technology is treated as non deterministic (ie, it does not determines social and organisational issues). Noble (1979) and Hughes (1984) have documented the socio-political character of technology (artefacts), technological development (design), and technological change (implementation of equipment). Moreover, as technical artefacts are socially shaped, they might have political qualities. That is, technology can be designed and implemented in such a way to support or constrain the use of a particular technology for specific purposes (Winner, 1985). This does not mean, however, that social issues solely determine technical content. Technology, at different stages (design, development, implementation and current usage), plays different roles varying according to the social forces trying to influence both its technical role (eg performance) and the socio-political role that it might fulfil at each stage.

Soft-determinism supports the idea that technology allows certain social choices and constrains others. The enabling feature of technology means that technology features (that were planned and designed by other people) might allow its utilisation in some ways, but that does not involve the compulsory use of those specific features of technology. The constraining feature of technology is related to past choices made by earlier technology designers. New improvements on a machine, for example, can only be performed as far as they are compatible with an earlier technical model. Earlier design choices then may constrain certain forms of utilisation of that technology.

Configurational approach. In the present study both technology and organisational factors are taken as being of a configurational nature. The configurational view approaches manufacturing systems as an entity that made up of inter-related parts that posses the following features (i) each part possess different features, functions and outcomes; (ii) each part can change overtime (ie a part' feature, function and outcome may change); (iii) parts are linked by varies degrees of dependency; (iv) that linkage, in turn, may change over time, resulting in a different arrangement of the whole system; and (v) each part has components which are of a configurational nature. Meyer, Tsui and Hinings (1993) have further developed particular features of configurations.

...configurational inquiry represents a holistic stance, an assertion that the parts of a social entity take their meaning from the whole and cannot be understood in isolation. Rather than trying to explain how order is designed into the parts of an organisation, configurational theorists try to explain how order emerges from the interaction of those parts as a whole [...] Nonlinearity is acknowledged, so variables found to be causally related in one configuration may be unrelated or even inversely related to another. Configurational theorists expect organisations to alternate between disequilibrium and equilibrium, with discontinuous change punctuating periods of stability. Change is seen as episodic, in part because

organisations are tightly coupled. The couplings are pliable up to a point, but if stretched beyond that point, they actively resist change. Since major organisational changes are assumed to occur in rapid transformations from one comparatively stable state to another, configurational researchers often design longitudinal studies, and theoretical accounts stress time dependence and history dependence. In acknowledging that there is more than one way to succeed in each type of setting, the configurational approach explicitly accommodates the important concept of equifinality. (p. 1178)

In order to explain the functioning of both technology and organisations it is necessary to conceive them as whole complex systems, rather than as simple assemblages of parts.

Technological configurations, therefore, can be defined as the total range of arrangements which a group of parts (eg machines, equipment, software) can form considering both supporting and constraining technological features as well as social related decisions.

Configuration of component technology may be made up in a very wide (in fact arbitrary!) range of patterns. The mutually interacting (but not necessarily mutually constraining) components may be deployed in a very wide, possibly arbitrary, range of ways in order to match externally set requirements ... The crucial point about configurational technologies, therefore, is the lack of any internal standardisation, or stability in the overall system performance requirements. Requirements are not internally set by the system itself, but have to be explicitly decided by the users, in the light of the particular application addressed. Hence, the active involvement of the user is necessarily called for (Fleck, 1993:8)

Organisational configurations are defined as the number of forms which organisational components may take. Organisational structure, mechanism to control work, ways to co-ordinate/divide work, work structures, manpower skills, training, rewards and career policies, workers' participation/involvement policies as well as the way people are deployed in the manufacturing system and its associated social system⁷⁶, are key components of the organisational configuration. Not only can each of these dimensions be configured in different ways, but each one also possesses parts which are of a *configurational* nature. Moreover, during the implementation process, social actors might 're-configure' the original organisational form to accommodate their particular goals and interests⁷⁷. Thus, the existence of a wide range of configurations of work and organisational structures is possible.

Organisational configurations are as dynamic as the intentions/goals/interests and power positions held by social actors who configure the key organisational components. Work and

⁷⁶ Social system, in the case of a manufacturing system which uses computer-based information systems for example, involves first, the social context in which the computerised technology is developed and used. Second, the infrastructure of support for the system -including the social organisation of access- and the history of social arrangements in which the computerised technology was designed, implemented and developed (Kling and Scacchi, 1982; Kling, 1991).

⁷⁷ Managerial decisions for example, are not only taken on the grounds of purely technocratic rationality to decide the final form of the above organisational dimensions, but also they are motivated by: power relationships, intentions and personal politic goals (Mintzberg, 1990).

organisational structures, for example, can be configured in multiple forms that can range from a high division of labour/greater specialisation/greater direct control ('technocentric approach') to low division of labour/lower specialisation/non direct control (human-centred).

The idea of organisational configuration is useful because it focuses more on synthesis than on the analysis of individual variables. In other words, it makes more sense to talk about networks of interrelationships than about any one variable driving another (Mintzberg, 1989:96).

Processual Approaches (cf Dawson, 1993; McLoughlin and Clark, op cit; Clark et al, 1988; Badham, 1994) of organisation, work and technology, understand organisation as the arena in which ongoing piece-meal processes occur converging issues related to technical, organisational, social and political rationality. Processual approaches are useful as they emphasise not only the complexity of organisational change with its associated stages in which negotiation occurs between different social actors (Wilkinson, 1983); but also support a soft determinist approach in terms of the fact that, depending on the way technology is designed, implemented and used, some choices are eliminated and others supported. Processual approaches complement configurational views as they allow for a more comprehensive understanding of the different forms both technological and organisational components can take at different stages of the change process.

This approach considers not only internal factors but also external ones to explain organisational actions. This is important, as some approaches towards organisation underestimate or simply exclude the influence of external factors. Managerial hierarchies, workers' power bargaining and technical constraints for example, are some internal factors that influence organisational developments. Government policies, trade agreements and market environment are some external factors considered in this approach⁷⁸.

In order to understand the functioning of complex manufacturing processes, the above concept of configurations, the social construction of technology and processual approaches of change, are integrated to with the MES idea. A soft determinist view of MES functioning is presented, based on, the general idea that complex manufacturing systems are composed of technology, organisation and people (called technology 'users'). The combination of these three components allows the functioning of a manufacturing system. Because of technical

⁷⁸ Other processual approaches exist. Orlikowski's (1992) *structuration model* of technology for example, not only incorporates the social construction of technology perspective but also widens it by incorporating institutional conditions that influence the way technology is designed and applied. It also explicitly recognises the dynamic nature of contextual conditions by suggesting the relevance of time and space factors, in the examination of technology usage.

constraints, these three components can only be combined in a limited number of ways. Thus, the MES notion provides us with a systemic view of a manufacturing system (ie since all parts are related to all other parts, changing one part will affect others) and explains how the technical limitations of the whole manufacturing system (ie constraints defined by the system architecture and system configuration) might limit choices made at the micro level. Simultaneously, the idea of organisational configurations helps us to understand the different forms organisation and technology can take, as well as the associated socio-political processes that occur when technology users do work. An MES that follows HC guidelines then, can be labelled as a Human-Centred Manufacturing Systems (HCMS).

4.3 THE CONCEPT OF HUMAN-CENTRED MANUFACTURING SYSTEMS (HCMS)

Exhibit 4.1 displays a general overview explicating the key interdependent forces that shape the final form of any manufacturing engineering system. There are three stages in the development of HCMS. First, outside the firm, both labour and product markets play an important role in informing and providing the means for management to take strategic decisions regarding product type and target markets⁷⁹. However, it should be noted that, as will be argued in chapter 3, industrial organisations are inserted in a particular national context with specific societal values, norms, industry policies, laws, levels of economic activity and other institutional arrangements.

Second, in the design stage, management choose specific product and target market strategies to follow, based on product and labour market forces. Based on product and market strategy, both technological and organisational components are designed by manufacturing systems designers (ie usually management). This involves the study of 'Human Factors' involved in the interaction of people and technology⁸⁰. The definition of the firm's business strategy (ie defined product and market strategies) is important for the application of HC principles as

⁷⁹ Considerations regarding product and labour markets and its relationship with HCMS are made in Chapter 7.

⁸⁰ 'Human Factors' are defined by Meister (1989) as '(1) analysis, measurement, research, and prediction of any human performance related to the operation, maintenance, and use of equipment and systems; (2) research on the behavioural variables involved in the design of equipment, jobs, and systems; (3) the application of behavioural knowledge and methods to the development of equipment, jobs, and systems; (4) the analysis of jobs and systems to assist in the optimal allocation of personnel roles in system operations; (5) research on the experiences and attitudes that equipment users and system personnel have with regard to equipment and systems; and (6) study of the effects of equipment and system characteristics on personnel performance' (p. 47)

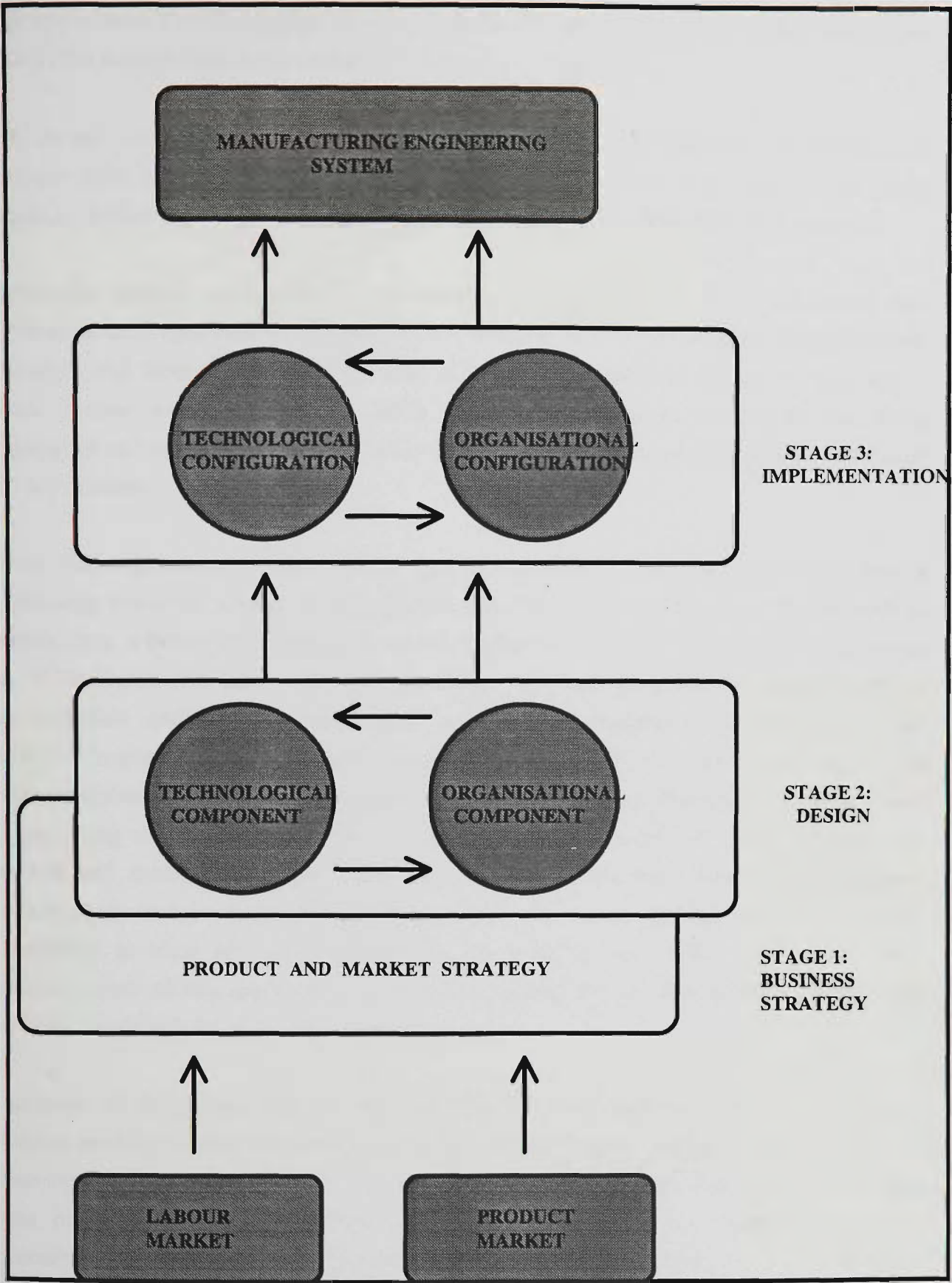


EXHIBIT 4.1: THE SHAPING OF MANUFACTURING ENGINEERING SYSTEMS

Sorge and Streeck (1988) suggest, the HC model is adequate only in high quality customised markets (this issue is empirically tested and discussed in chapter 9).

Third, during the implementation stage, both technical and organisational components are reconfigured (by technology users, vendors, implementators) in their final form. At this stage, technology users play an important role in the final shaping of the manufacturing system.⁸¹

Keeping this general approach in mind, HCMS is examined. It should be noted that technological and organisational components are mutually interdependent and selected factors (ie product and labour markets) influence, together with technical limitations and socio-political choices, the final form of the MES. Additionally, congruence between and among technological and organisational components of the MES is suggested (this issue is developed in the last section).

Conventional engineering wisdom, usually approaches manufacturing systems as possessing the following functions: design, manufacturing and distribution of products. Within each of these functions, a further three simultaneous processes occur in order to obtain the desired aim (Bell, 1972; Hubka and Eder, 1988; Sailor, 1990). They are: (i) a transfer system exists to move materials and/or data inside and outside the manufacturing facility; (ii) the transformation process, which transforms data and/or materials into a particular output; (iii) the control system, which co-ordinates all the elements of the manufacturing system to ensure the functioning of the transformation process. Traditionally, each of these processes are developed and studied separately. Current Production Operations research, for example, focuses not only on topic issues but also uses methods that, in the majority of cases, can only be replicated in ideal laboratory conditions (Meredith et al, 1989). Thus, the purely 'mechanistic' view of this approach is its most outstanding feature. Social factors and people are seldom mentioned, let alone their joint examination.

The concept of technology involves not only hardware and software but also the human knowledge needed to make technology work and its application in different ways. Therefore, engineering manufacturing systems '... are not just pieces of hardware and software, but also systems based on certain engineering principles and composed of elements which are functionally arranged (configured) in certain specific ways' (Clark, et al, 1988:13). MES can also be approached as 'technological systems' in the sense that they are a group of related artefacts that,

⁸¹ The implementation stage is analysed in section 5.

... are both socially constructed and socially shaped. Its components are artefacts, organisations, scientific components such as books and research programs, and legislative artefacts. All these components are inter dependent and the change of one of them could change the shape of the others. A crucial function in technological systems are the role of people that belong (but are not 'components') to the systems. In order to control them, inventors, system builders, managers use hierarchy, and the definer of the technological system can be political (Hughes 1984:53-4).

Organisational components of the MES include: work and organisational structure patterns, reward systems, training policies and the skill level of the workforce. Users of technology are a special "component" of the manufacturing system as they are configured and are, at the same time, MES 'designers'. During the implementation stage, they play a key role in reconfiguring their own role, technology and organisational components.

Technological artefacts, technology users and organisational structures are configured within the boundaries of the system configuration and systems principles, what McLoughlin and Clark (1993), call 'system architecture'. Technical artefacts, organisational components and technology users, are deployed inside the MES configuration. As observed in Exhibit 4.2, MES possesses the following key dimensions that bound technology, users and organisational configurations:

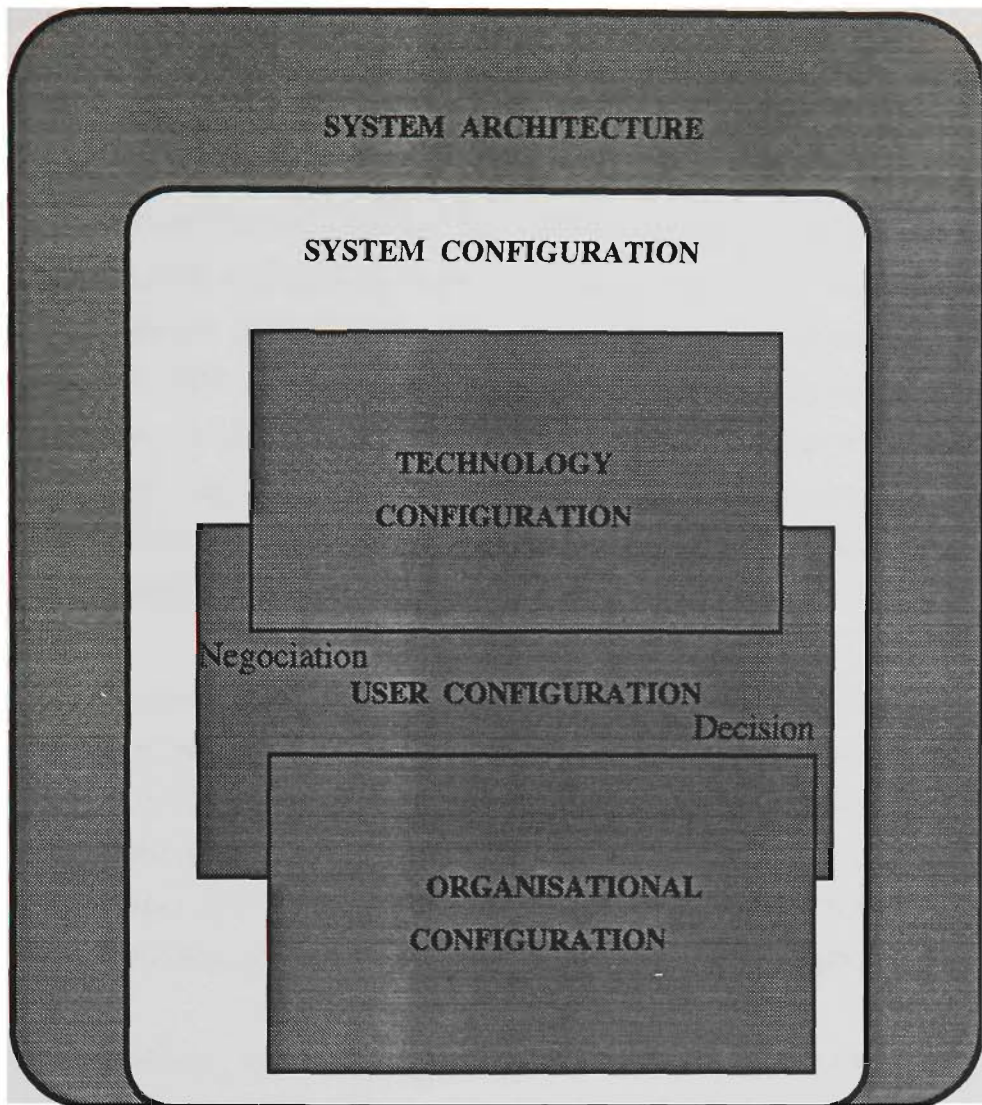
(i) System Principles. Checkland (1981) argued that a system should be approached as a self-correcting and context dependent whole entity, characterised by control mechanisms and communication patterns with particular features)⁸². Systems can also be linear or complex. Because complex systems are more efficient in adapting themselves to uncertain manufacturing conditions than linear ones, complex systems possess a significant advantage in these situations⁸³ (Simon, 1962).

(ii) System Configuration. This might be considered a special kind of open system, with particular features that allows technical and organisational components to be implemented in different ways.

(iii) System architecture, therefore, may be defined as the general technical-based framework in which all other components of the MES can be configured. This definition is soft-

⁸² There has been however further theoretical developments concerning the notion of systems including the idea of the existence of non-instrumental systems and the fusion of several wholes to form a more complex whole which is not necessarily purposeful. For details see Atkinson and Checkland (1988).

⁸³ Perrow (1984) explicated common features of complex systems: "proximity of parts or units that are not in a production sequence; including the many common node connections between components (parts, units and sub systems) not in a production sequence; unfamiliar or unintended feedback loops; many control parameters with potential interactions; indirect or inferential information sources; and an limited understanding of some processes"(p. 85).



**EXHIBIT 4.2: MANUFACTURING ENGINEERING SYSTEMS:
A CONFIGURATIONAL/PROCESSUAL APPROACH**

determinism biased as it recognises limitations that the technical base puts on other components of the MES. At the same time the configurational feature of the MES signals that space exists to arrange MES components in a limited number of ways. That is, technical artefacts, organisational components and users of technology are of a 'configurational' nature. Because both technological and organisational configurations are socially constructed, they and their individual components can be deployed (by its designers, developers, implementators and users) in a wide range of forms. Different modules of a CAD system for example, can be configured in a limited number of ways by management, users and technology vendors. In a similar way, organisational components such as work structures and reward systems can be configured by management, who in turn may be influenced by labour market. However, the system architecture of CAD technology (ie its data base features, type of interface, maximum number of workstations, power processing, among other 'technical' factors), limits the number of ways the technical (eg the specific functions that a workstation can perform) and organisational (ie the specific forms of co-ordinating activities between central and remote workstations) components can have.

Technology users are configured by management during the technological and organisational components' set-up, by placing constraints upon their likely future actions (Woolgar, 1991). However, it should be noted that users might reconfigure their role in the manufacturing process by reconfiguring selected technological and organisational components. In other words, technology users are not only socially constructed but they may be permitted designers or illegitimate actors/constructors of their own configuration (Hales, 1992)⁸⁴.

That is, individual machines, work stations, groups of machines and technology users, can be deployed in a limited number of ways as long as it follows the general rationale of the overall system configuration. This is the reason behind the soft-determinism approach embraced in the present study: within the system configuration, each component of the organisational and technical configuration can be deployed in different forms. The defining factor of the technological and organisational deployment process, are the negotiation and decision processes that occur, between technology users, manufacturing systems designers and implementators, during the design and implementation processes.

In the present study, the view is taken that socio-organizational factors, that is, the political processes of choice and social negotiation are more important than technological factors in the setting up of the final configuration of technical artefacts and organisational components

⁸⁴ For further explanations of different types of users, see section 6.

(McLoughlin, 1993)⁸⁵. Three reasons sustain the emphasis on socio-organisational issues to explain MES functioning. First, "[T]he relevance of technology lies in the interpretative creations of such [human] actors rather than in any objective account of the capacities or effects of the technology" (Grint and Woolgar, 1992:76). Second, the fact that successful use of technology seems to be highly related to people issues rather than to technical ones (Ingersoll Engineers, 1984). Third, the non deterministic nature of technology.

Conceptualised in this way, the HC view developed here uses the idea of MES as an alternative concept to overcome key shortcomings of the socio-technical systems approach, from which the HC view is derived. First, by promoting a new orientation in the design of technology, the HC view addresses the technological determinism factor. Second, in the functioning of the manufacturing system, there is room for capital/labour conflicting views to negotiate as the key role of the technology user in the setting up of both technological and organisational configurations is acknowledged. Third, the influence of external forces in shaping the way technical artefacts and organisational components are configured is acknowledged. Four, by treating people (ie technology users and management), organisational factors and technology as configurations, the HC approach overcomes a key problem in the conceptualisation of production models, that usually prescribes the role of key components. That is, using the MES concept, as defined above, each of its components, possess enough room within the operational constraints of the system architecture. In this way, the MES concept is useful for explaining different production models, from taylorism to HCMS. Keeping in mind this view of manufacturing systems, the different stages that shape the manufacturing system are examined separately in the next sections.

⁸⁵ It should be acknowledged here that the way orthodox organisational theory explains manufacturing systems behaviour is controversial as different theoretical lenses stress different social actors at different levels of analysis. They partially capture the complexity of organisational reality. It must be noted, however, that while some views might be conflicting, they are not necessarily wrong in the sense that different theoretical lenses better explain different contextual conditions associated with the way technology is designed and applied. While the strategic choice approach (Child, 1984) for example, rightly stresses the importance of managerial power in the way that a firm is structured and managed, labour process theory (Bravermann, 1974) explains organisational change merely as a means to increase managerial control over the workforce. Furthermore the contingency approaches (Lawrence and Lorch, op cit) emphasise the importance of using appropriate organisational structures to fit environmental conditions, but treats technology, and other external factors, as simply given.

4.4 DESIGN AND PRINCIPLES OF HCMS

4.4.1 HC Technology Design and Principles

In this section the design of the technology stage is examined as a key premise of HC theory. Moreover, the redesign of existing (technocentric) manufacturing technologies is argued by HC theorists (cf Brodner, 1987; Corbett et al, 1987) to be a necessary condition for establishing HC organisations.

The design of technology is important because of: (i) its influential, but not deterministic, role in establishing production organisation⁸⁶; (ii) the political qualities embedded in the technology development and application. Modern technical artefacts, for instance, have often been developed following a mechanistic view of human beings concerning their role in the manufacturing process⁸⁷. This means that the traditional design of machines and ancillary equipment is often based on the assumption that effective machine design means minimising human intervention. Human participation in the process of manufacturing is seen as an unreliable intervention, because of the uncertainty and non-predetermined features of human actions. Thus, technology designers usually try to minimise human intervention in productive processes, including product design activities.

Classical methods of system design promotes the “unmanned factory” ideal of obtaining manufacturing systems capable of automatically recognising and diagnosing faulty operations as well as incorporating automatic solutions to all disturbances (Hatvany, 1985). However, because of the different contextual situations that might occur in the use of the manufacturing system, the knowledge necessary to design machines able to recognise and correct environmental disturbances is still not enough⁸⁸. “...No algorithms can be written which foresee every possible failure made of a highly complex system, nor can remedy strategy be deterministically designed for every situation” (Hatvany, 1985:394).

⁸⁶ Perrow (1983) argued that, as designers have the power to provide standardised or varied equipment, their choice may influence organisational structure

⁸⁷ Despite the recognised limitations of this strategy, its utilisation seems to be widespread. Salzman (1991), for example, after reviewing more than 100 books on machine design concluded that the traditional approaches of design “are rooted in principles of taylorism and the mechanistic view of humans” (p.36). He asserts that ‘human factor ergonomics’, have a limited focus since designers are worried only about the establishment of parameters of human physical activity to achieve optimum machine performance.

⁸⁸ Ingersoll Engineers (1984) for example, have pointed out that sophisticated diagnosis and error correcting systems are not only commercially available but also that ‘if [error recovery system] is too sophisticated it could be too expensive and complicated and be liable to failure itself’ (p.67).

The corner-stone of the HC approach to design technology lies in the recognition of the limitations of technology. Rather than substituting or degrading human intervention, advanced manufacturing technological systems such as an FMS unit, require a higher quality of human interaction with the system (Bainbridge, 1983; Jones, 1989). Therefore, skilled human intervention is necessary to complement machine capabilities. This is the central assumption of the HC approach to the design of technical artefacts.

The proponents of HC systems have attempted to change the design of the technology process to allow a greater 'openness' when applying technology to different work situations, as well as making HC restructuring work feasible.

The aim is to influence the direction of technology in order to produce economically and socially acceptable automatic systems. This implies the avoidance of the degradation of human work where people are made subordinate to machines. The change of the current design process of technology itself, with all its basic assumptions, and the improvement of human-machine interfaces is necessary to improve both technical efficiency and working conditions (Rosenbrock, 1989). In order to effectively influence technology design, a multidisciplinary team, lead by Professor H.H. Rosenbrock, was set up at the University of Manchester Institute of Science and Technology (UMIST) in the early 1980's. The ESPRIT Project 1217(1199) further developed this idea developing HC CAP, CAM and CAD technologies⁸⁹.

The design process involves four general stages (Corbett, 1986). The first of these is the outlining of the desired features of the equipment. The second is the consideration of the system design or the determination of the system architecture that embraces the unrefined hardware and software functions. The third, details the alternatives available. Fourth, the testing of individual solutions. Because of the intrinsic subjective features of the judgement made by the designers during the analysis, synthesis and evaluation of each of the design stages, it is difficult to reduce all intervening factors to a specific method. Rather, the design process calls for the application of tacit knowledge and therefore cannot be reduced to methodological canons (Corbett, op cit).

Corbett suggests that a good design must develop several possible alternatives and involve the user in the design process. However, the UMIST team found that user participation in the design process was of limited value because of lack of user understanding. The intrinsic nature of the design process, which is highly creative and involves problem solving activity, as well as

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For details see Murphy (1992)

negotiation processes that occur at all stages, are factors that explain lack of user understanding⁹⁰.

Corbett (1987a,1990) details the points in the design process at which social choices are possible. It is important to note that earlier choices made in the design constrain choices to be made later. The system design process, allocation of functions, control features, information characteristics, are the principal points of social choice.

1) Design process. The first social choice point occurs when system developers choose which method they will use to design, that is, make decisions about the design process to be used. The traditional design process embraces a sequential method assigning priorities to factors involved. Usually, technical factors are considered first and social or human factors are either not considered at all or are considered only after the design options are made, based on technical issues. Therefore, social factors do not have significant participation in the final shape of the technology.

In the HC approach to design technology, a parallel sequence is followed. That is, human factors and technical factors are taken into consideration at the same time. Therefore, the final form of technology reflects both technical and human factors. As some of those factors can be conflicting, the aim is to obtain a moderate equilibrium among them and not to optimise both at the same time as that is not feasible.

2) Allocation of functions has implications for the design of operating tasks. It possesses two dimensions: allocation of functions in the human-machine interface and allocation of functions in the human-system interface. The traditional approach is usually based on a comparison of the capacities between machines and humans. That is, the operator performs those functions which cannot be automated or are too expensive to automate.

In the HC approach, the operator performs tasks depending on the specific production circumstances. Complementarity between humans and machines is the basic HC criterion for allocating functions. Humans perform tasks that require full use of their skills. These include knowledge, experience, manual ability and creative behaviour in the face of unexpected events. In other words, humans perform functions prone to disturbance and uncertainty within this approach. Machines perform routine, unsafe and predictable tasks. Technology, in this approach, must be designed in such a way as to allow maximum usability (Adler and

⁹⁰ The UMIST team for example, had problems when it tried to involve users in all the stages of the design process. The users did not provide alternative solutions and pointed out only the deficiencies of the system.

Winograd, 1992). That is, the technological manufacturing system should support the users' potential to work/understand/learn and subsequently modify the system. These principles inform the task allocation criteria developed at UMIST (Corbett, 1989):

(i) *Compatibility*. Interaction between operator and machine must be based on a language designed to facilitate the operator's understanding of machine feedback. 'Machine level' language must be replaced with a 'operator level' language. This operator level language must be compatible with the operator's current training and experience.

(ii) *Transparency*. In order to control and accept responsibility for machine operations, the operator must receive information regarding internal machine processes. Therefore, the operator's understanding of any internal model used to process information by the machine is important for work performance. The better the operator's understanding, the more 'transparent' the process. This criteria allows the operator to know exactly what the machine is doing, and why. In the case of an unexpected event, the operator's knowledge of the current status of the process, would eventually allow him/her to take corrective actions on-line.

(iii) *Accountability*. This item complements transparency. In order to achieve a high degree of transparency, software architecture must be self-descriptive. This feature would allow the operator to receive enough information from the machine, in real time, to know which part of the process (computer program) is being executed.

(iv) *Minimum shock*: The machine operator should be informed about the next machine operation before hand. This feature would assist in the operator being able to respond quickly in case of unexpected events or the machine needing attention.

3) Control characteristics of human-system (human-machine) interface. This involves decisions about how the control of the system will be shared between human and machine. The more the control of technological components resides with the operator, the more work in the productive process will be human-centred. That is, work is performed at the operator's discretion. The key criterion for deciding control issues, found by the UMIST team, is that the control of the machine at the point of operation must be shared between human and machine reflecting the main capacities of each. Thus, routine tasks are 'controlled' by the machine and uncertain tasks are operator controlled with the machine's support.

Under the traditional approach, the control features of human-system interface (machine-machine) are centralised. That is, production machines are controlled at the highest possible level. For example, CNC operations are controlled by a central mainframe. Conversely, the

HC approach advocates a decentralised control system. That is, machines must be controlled at the lowest possible level. The possibility of correction of an NC program at shopfloor level is an example of the latter. Thus, it is necessary that during the design phase all those factors are considered.

4) The information feature of the human-system interface is important for the design of jobs and for operator performance. To the extent that the system allows the operator to understand and know the status of information of all the variables involved in the machine functioning, operators will possess greater or lesser information to cope with malfunctions during the production process. While shopfloor information is limited to high managerial levels in the traditional approach, data base information is available to all personnel in the HC perspective. It is suggested that when the information is used near to the point where it was generated, the systems will tend to be more efficient "Complementarity of human and computer control relies on the design of the interface between them, on the medium and type of information and operating strategies that the two must exchange" (Corbett, 1989:34).

5) The allocation of responsibilities between personnel is constrained by the design choices made above. It embraces the way work is divided and distributed among production personnel in the design and manufacturing spheres. Both management decision-making power and workers' associations play a significant role in the establishment of a work organisation. The latter can, to a great extent, overcome the constraints made by the designers of the technology. Yet, this point remains open to debate and is discussed in detail in the next section.

Practical limitations were raised in applying these criteria in the UMIST project. For example, in the 'blank table debate', which concerns the development of NC human-machine interface criteria, the UMIST team did not reach an agreement concerning two vital issues. The first is deciding to what extent software must propose alternatives to the operator. The second, is to what degree the operator must decide to use or change those alternatives and the conditions in which to do so. The operator, for example, may or may not be influenced by machine calculations, or he/she must determine the values to be fed into the machine. Furthermore, the optimum degree of transparency of the software must be decided.

The application of the 'keep the options open' criteria, was also problematic. Because of the nature of the design process (ie basically an activity of closing options), it is difficult to achieve the above specific goal. Aside from that, two other disagreements occurred in the UMIST project. First, there were not any defined criteria to determine the priority of the available options. The second concerned skills. They did not agree about whether technology

must be designed to maintain the old skill demand, or if it should create new ones or eliminate the 'unnecessary' tasks and skill related demands (Rosenbrock, 1989). With regard to the same issue, ESPRIT initiatives for designing HC technology learned that,

It is often the case that no solution to a particular design problem meets all criteria. Engineers design always involve making trade-offs between implicit and or explicit technical, economic and social criteria. The inclusion of explicit human-centred design criteria in this process largely serves to further complicate the situation, and it is therefore crucial that design criteria are complemented by methods to enhance their usability (Corbett, 1988:38).

It is worth noting that, beside the work of the UMIST project, other viable technologies developed as examples of HC design methods exist. In Germany for example two basic manufacturing technologies supporting the establishment of HC principles were developed (Baudemer, Henning & Hilbert, 1990) ⁹¹. These were Work Oriented Programming and decentralised Electrical Control Systems.

The Work Oriented Programming (WOP) technology was developed by the German firm Traub. The basic idea is to enable the NC machine operator to produce a component in the same way as in a conventional tool machine using his/her regular qualifications and experience. NC technology can be used both in the programming department or on the shop floor. The complexity of the program required and the availability of skilled operators would, to a great extent, influence the decision of where the programming activities will be done. However, it is important to notice that the decision is also a managerial prerogative. In other words, it is the organisational factors and the degree of openness of the system that determine the work organisation⁹².

⁹¹ Two key factors influenced the development of skill-based oriented technology. Namely, effective R & D government policies and present market forces.

⁹² A Traub (1990) publication pointed out the principal features of this interactive programming system in a turning NC machine:

(i) definition of complete machining sequences using easily understood symbols which originate from common turning practice; (ii) inputs in graphic interactive dialogue to directly inform the turner of the effect of each input. The turner is then in a position to change or optimise individual steps immediately; (iii) when defining the finished part contour, input of drawing dimensions only or, alternatively, transfer of CAD-data to the machine; (iv) easy access to similar working sequences regardless of whether these are stored within the machine control system, or remotely in a programming station; (v) full technology support, such as automatic calculation of all metal-cutting data (tool shape, tool tip material, cutting data) dependent on material, workpiece shape and machine data of particular machine in use; (vi) setting suggestions - particularly important when producing one-offs or carrying out repeat production; (vii) high reliability level through real time and true graphic simulation of all programmed sequences; (viii) rapid setting and measuring of tools mounted on the machine.

Decentralised Electrical Control Stations (ECS) allow the decentralisation of the planning and scheduling (control) of production operations. This is an interactive graphic scheduling system that helps the operator to plan the detailed shop floor scheduling. Baudemer et al (1990) noted that both technologies allow their utilisation in centralised or decentralised production systems. Despite the existence in the market of such technologies designed to favour decentralised work structures, the dominant pattern diffused is of a technology designed within the traditional mechanistic approach which is commonly used within tayloristic work structure patterns (Lay, 1990).

4.4.2 HC Organisational Design and Principles

This section examines design and principles of the organisational configuration. Building on the organisational theory, this section presents important concepts which are all related to HC organisational forms, and discusses how the different components of the HC organisational configuration would look like under the HC approach. Before this, the concept of organisational design is recalled.

Organisational design involves the setting up of broad goals and policies in an organisation as well as defining how tasks and functions, at different levels, are divided and co-ordinated. This means allocating functions and responsibilities to individuals and groups, designing co-ordination mechanisms and, defining the number of levels in the hierarchy. Organisational design also establishes mechanisms to control functions and seeks to motivate employees. In this latter category are included, authority delegation, monitoring of activities, detail objective setting, training policies and staff evaluation (Buchanan and Huczynski, 1985).

Now we turn our attention to HC organisational design and principles. This involves examining HC forms of work and organisation (eg workgroup) as well as 2 key supporting activities: skill structure and training practices.

Empirical research (cf Schultz-Wild, 1990; Gottshalch, 1990; Kotter, Gohde and Wever, 1990; Martensson and Stahre, 1992) suggests that work and organisational structures possessing low division of labour, high decentralisation, appropriate integration level among and between different work units, as well as shopfloor workers possessing enough skills to perform execution/planning/co-ordination/learning/monitoring activities, can successfully cope with complex and uncertain tasks. That is, they are not only socially adequate but also technically and economically effective (Kopacek, 1989; Martensson, 1989).

Organisation decentralisation and integration are key features of the HC model as they seem to cope better with the uncertainty and complexity of tasks. Decentralisation and integration,

which occur differently inside and between work units, are examined firstly and distinctive HC organisational features existing inside and between work units are examined secondly.

Organisational decentralisation is a key feature of HCMS because decentralised organisations are more efficient than centralised ones for coping with situations of high task uncertainty and complexity⁹³. This is due to the values that decentralisation entails: quick responsiveness, reliability, adequacy, and quality of required service (Kochen and Deutsch, 1980). The 'value' of decentralisation, therefore, is a function of the extent of decentralisation. Decentralisation refers to whether or not the unit of work is planned and minutely controlled from a superior authority or under an 'autonomous' and self-controlled (and planned) approach. The degree of decentralisation is related to the specialisation and degree of discretion needed to perform the task (Child, 1984).

The traditional organisational arrangement by functional specialisation is an example of a centralised work structure, in which workers' tasks and responsibilities possess clear boundaries, and these are narrowly and minutely planned. They are differentiated by specialisation and the vertical and horizontal division of labour is pronounced. Hierarchical and systematised mechanism of control exists to govern inter-task relations.

Decentralised organisational structures imply lower levels of specialisation and higher levels of discretion about the immediate reality of work. Lower level of specialisation means low horizontal division of labour, such as the work of a highly homogeneous skilled group. A high discretion level implies the enjoyment of enough autonomy and skills to self-manage decisions such as how, when and who should perform particular tasks within the group. It is necessary to recognise that decentralised work structures do not necessarily imply a decentralised organisational structure. Advanced manufacturing technology is able to be deployed flexibly in both centralised and decentralised organisational structures, technology itself influences the degree of (de)centralisation achieved in the final form of work organisation to a small extent only⁹⁴. To be efficient, however, decentralised work structures are required to be both technically and organisationally integrated⁹⁵.

⁹³ This general statement is in fact shared by both organisational writers such as Perrow (op cit), Child (op cit) and technical writers like Senn (1990). The latter, for example, claims higher productivity of computer-based systems. Because up to 60% of system maintenance activities are refinements of applications, this can be done by end-users and not by specialised technical personnel.

⁹⁴ In fact, CAD technology for example, increases options for organisations to centralise or decentralise, including the options to do both (Majchrzak et al, op cit). This implies that management can use new technology either to subordinate the workforce or to empower it (Dean, Yoon and Susman, 1992).

⁹⁵ In manufacturing environments where computerised microelectronics technology is used, integration tends to be through technological means. However, this will not automatically result in a high organisational integration level. Information technology 'integration' does not encompass organisational integration. The

Technical integration refers to the interdependency established as a response to the technical need of the production process ⁹⁶. A manufacturing cell⁹⁷, for example, that feeds other cells, needs to be technically integrated to allow for parts/materials to flow between cells in such a way as to avoid constraining the feeder or receiver cell. This is not only related to the material but also to the efficient inter-exchange of technical information between the involved units. HC technical integration implies the existence of a decentralised linkage of data flow. This provides favourable conditions in which organisational integration can be achieved⁹⁸.

Organisational Integration refers to the organisational mechanisms adopted to relate the way workers and their attached functions perform inside and between work units. HC organisational integration involves work and organisational structures that support : a high degree of exchange of information, and workers' self-regulation (responsible autonomy). Because task complexity levels increase in terms of uncertainty and interdependency when

use of integrative organisational mechanisms is also necessary to complement the higher or lesser 'integrative' nature of the technology.

The use of new manufacturing technology calls for the application of organisational integrative mechanisms. Majchrzak et al (1987) asserts that the efficient utilisation of CAD technology, for example, depends to a great extent on human factors such as attitudes, fears, recognition and incentives. Because human factors are related to the complexity and interdependence level of design and/or manufacturing tasks as well as to the micro-organisational power relations, efficient use of technology needs the co-operation of users. Application of organisational integrative mechanisms support that co-operation.

⁹⁶ This concept should be differentiated from Scheer's (1990) technical integration concept that approaches integration as electronic linkages of information flows(i) inside the manufacturing system; (ii) between manufacturing process; and (iii) between suppliers and customers.

⁹⁷ Cellular manufacturing is a multi-skilled, multi-process production unit in which each part or component is totally completed. This eliminates additional workflow between other productive areas, simplifying planning and control activities. Cellular manufacturing allows the modular implementation of different computer-aided technologies (eg MRP, CAP, CAM) and organisational techniques such as JIT and TQM. The application of cellular concepts allows not only productivity gains but also important self-governance gains for direct workers (Alford, 1994:3-14).

⁹⁸ Three basic ways to achieve the totally integrated system can be identified (Hatvany, 1977:23-4). First, putting things together, (ie by linking the existing data processing and material processing functions). Second, using data processing and material processing equipment which posses standardised interfaces to facilitate their communication. Finally, by designing a priori the entire integrated system. While the first approach is less efficient, universal and transferable it is also the easiest to follow. The second one is the most common at present. The third approach, while it is more complex and work demanding is being used increasingly because of the frustrating results of the second option.

Each of these methods to develop integrated systems can be developed under different approaches from tayloristic-like to HC-type. The difference amongst them is that in the first method, as the basic technological components are already developed, it is difficult to 'insert' any human-centered criteria. In the third method, it is possible to incorporate HC criteria into the design process. The second one can offer, equal possibilities to include technology-centered or human-centered design criteria.

using computer-based manufacturing technology in volatile/high quality markets (Cummings and Blumberg, op cit), personnel tasks need differentiated support from different sources. Hence different managers may be responsible for the different tasks performed within the same work unit. The work unit needs to be supported by different specialists who might possess different values, culture, goals, interests and responsibilities. Thus, the application of integrative organisational mechanisms in the highly differentiated work unit is necessary (Lawrence and Lorch, 1967; Pugh, Hickson and Hinings, 1983). Organisational integration, therefore, relates to the degree of unity that a group of differentiated tasks or functions can achieve, and this is related to the existence of co-ordination mechanisms (Lawrence and Lorch, op cit). For example, matrix structure - an organisational structure with multiple commands - is a mechanism which helps to achieve integration in complex situations of differentiation and integration such as the one resultant from CAD/CAM systems utilisation (Davis and Lawrence, 1977; Winch, 1983).

The level of integration is also a function of the degree of vertical and horizontal division of labour. That is, the more vertical/horizontal division of labour within the unit work, the greater the need for a specialised workforce. This would bring pressure for lower levels of organisational integration. In order to accomplish the desired integration, then, the integrative mechanism needs to be used.

Organisational integration is important because it appears to be one of the sources of effectiveness. Bessant and Haywood (op cit), for example, suggested that due to the use of appropriate organisational structures that promote organisational integration, more than fifty per cent of the benefits occurring from using automation come before (manufacturing) technology itself is installed.

In addition to the adopted integrative organisational mechanisms (eg cross departmental teams, matrix structures), *two factors* are important for the achievement of organisational integration. First, the technology used to integrate data flows between work units; second, industrial engineering (organisational) techniques.

Microelectronics *technology* may help to enhance organisational integration because it promotes the linkage of physically separated workstations and has the ability to bring information from remote workplaces. This allows potential enhancement of managerial control⁹⁹, or potential reduction of hierarchical levels¹⁰⁰, or both. However, the above is not

⁹⁹ Child (1984) observed that the integrative feature of technology represents also the possibility for extending managerial control, providing faster and precise knowledge of the current operating conditions and results, by reducing the scope for indeterminacy in the employees behaviour and by unifying previously segmented control systems.

deterministic. It would result in higher or lower levels of integration and centralisation of information flows, depending on managerial goals to set up the organisational system's architecture. Yet, the type of technology used does influence the degree of organisational integration likely to be achieved. Lay, (1990) notes, for example, that systems architecture based on mainframe does not favour organisational integration within the HC perspective. Conversely structures in which a data base is created, used, administered and distributed by different departments, favours HC organisational integration and supports decentralised decision-making. But, this does not mean that in the former case, it would be impossible to achieve HC organisational structures¹⁰¹.

Several authors (cf Haywood and Bessant, 1990; Manske, 1983; Lockett, 1990; Kohler, 1986), have argued that the key factor in the establishment or non establishment of HC systems is not the technology but the way the organisation is structured. That is to say how information flows, how the division of labour and hierarchical levels are set up and how the decision making structure (that favours or constrains shopfloor personnel creative intervention) is established. To a degree, whether or not, technology is designed within HC principles, it is possible to use it within a HC production system or within other traditional perspectives.

A number of industrial engineering (*organisational*) *techniques*, such as group technology¹⁰² and cellular layout, have been identified as facilitating support organisational integration along HC lines. These techniques and principles can be applied both inside the work unit or in groups of work units.

Inside work unit. The workgroup is the organisational form that best assimilates HC organisational and technical principles. The organisational structure of the work group involves high task interdependence, job rotation, task (horizontal and vertical) integration, low division of labour, as well as an organisational mechanism to support personnel self-

¹⁰⁰ Integration of control information, by facilitating the flow of information from the shop floor to management, favours the contraction of hierarchical levels because of the redundancy of middle management levels and other support roles (Child, 1984).

¹⁰¹ Two kinds of organisational integration are possible within the HC perspective. First, the integration of as many functions as possible in one system operated by a single person. Second, the development of systems for each separate function such as NC programming, planning and production control and so on, all integrated by facilitating a data transfer between them (Finne, 1983). Indeed these two ways are complementary, and can be used simultaneously in an enterprise.

¹⁰² Brodner (1983) stresses the integrative features of group technology. It allows the establishment of low horizontal and vertical division of labour, hierarchical levels, and supports job enrichment and the full utilisation of skills.

governance (ie how to distribute tasks among group members), self-regulation (ie some power/authority is delegated or allocated to the group) and boundary control (ie the extent to which employees can influence transactions within their task environment: the types and rates of inputs and outputs). This latter characteristic, for example, enables the operator to 'control' the speed of the transport system if 'inter-activity' automation exists¹⁰³, or to establish adequate levels of buffer stocks of parts in process (Gerwin and Kolodny, 1992; Hackman and Oldham, *op cit*; Susman, 1976; Walton and Hackman, 1986; Sandberg, 1982).

This implies the use of some kind of 'responsible autonomy' (Friedman, 1977) strategy, that involves re-defining and re-locating elements/mechanisms used to control productive processes. Shopfloor workers enjoy a limited discretion inside their work unit. Direct control is substituted by output control.

While work group concepts are not new (cf Trist et al, 1963), their application is not easy or decided simply at the micro level. Macro contextual factors such as availability of skilled manpower, educational and training institutions, power relationships and level of organisation of worker's associations and, professional institutions among others, play an important role in shaping the type and form of the workgroups developed and diffused in a particular setting (Pearson, 1992; Litter, 1980; Cole, 1985, 1989).

In the current wave of manufacturing restructuring, different types of workgroups exist. Most workgroups do not comply with the extreme form of the HC concept. Some group work forms possess only part of the above mentioned features. Differentiation of HC from non-HC workgroups forms is crucial, as they possess different socio-economic agendas¹⁰⁴. An exemplary early form of HC workgroup was worked out by Kotter, Gohde and Weber (1990),

¹⁰³ Kaplinsky (1984) has differentiated integration at intra activity (eg a NC centre), inter-activity (eg linkage between two NC centres) within the same sphere (eg. design or manufacturing) and inter-sphere (eg, CAD activities electronically connected to NC program generation at shopfloor level).

¹⁰⁴ A handful of researchers (cf Oesterreich and Volpert, 1986; Weber, Resch and Volpert, 1986), have formulated a methodological tool (VERA methodology) to assess quality of work. That is, to what extent a human-operator uses his/her mental (creative) abilities such as planning and decision-making. This is an instrument that examines individual autonomy, task variety, task related opportunities for co-operation and communication and degree of group work autonomy. While this tool is very useful in examining quality of work at shopfloor level, it does not address the problem of type and quality of its associated organisational structures.

There are only two hierarchical levels in planning and performance: a so called planning and consultation group including members of Manufacturing Planning Control, NC-programmers, masters and an observer on the one hand and two working groups in production islands on the other hand.

The groups in the islands are responsible for all planning, controlling and supervising tasks for orders packets with weekly horizons. The NC-programming is partly integrated into the task spectrum of the island, but with clear allocation of complex parts to the programmers who are members of the planning and consulting group.

'Between' the production islands and the planning and consulting group, an operative forum called "shopfloor co-ordination team" with ad-hoc delegates of the several groups is installed. This shopfloor co-ordination meets for planning and controlling tasks on the middle-term level (order throughput with monthly horizon) and for common decision making related to the one-week order for the islands. It is also to prepare a raw weekly plan for controlling material flows between islands. [...] thus, the shopfloor co-ordination guarantees the close feedback loop between the direct processing and the preparing of functions in production.

The planning and consulting group is strictly relieved of the operative "daily business". It's members are now concerned with strategic and middle term planning tasks and with consultancy and substitution for the islands (p. 221-2).

Non HC forms of workgroups might, for example, bring positive economic results but with minimum relative autonomy through: (i) non-discretionary tayloristic job designs that exist even when some features of job enrichment/enlargement have already been implanted, implying that there is virtually no movement of workers from their work station except during planned breaks; and (ii) the planning and controlling of detailed workgroups activities by a supervisor (Conti and Warner, 1993; Naruse, 1991). Task design, under HC principles, has been found to be both economically and socially efficient. That is, a higher reliability for production planning and due dates and a higher need of skilled workers and higher worker morale has been identified by a number of researchers (Parker, Jackson, and Wall, 1993; Przygodda and Schmidt, 1993; Weber and Ulich, 1993; Kotter, Gohde and Weber, 1990; Kotter, 1992). Moreover, Auer and Riegler (1990) suggest that in highly industrialised nations, several macro factors favourable to the introduction and diffusion of semi-autonomous groups already exist¹⁰⁵. To illustrate these points, Exhibit 4.3 outlines the key differences between the non-HC workgroup, exemplified by the Japanese type workgroup, and the HC workgroup. This comparison refers to ideal types in both cases¹⁰⁶.

¹⁰⁵ The same conclusion can not be extended to semi-peripheral nations like Brazil. This key question is addressed in Chapter 9 of this study.

¹⁰⁶ Based on Hammarstrom and Lansbury (1991), Jurgens (1991), Susman (op cit) and Cutcher-Gershenfeld et al (1994).

Type of Workgroup	NON HUMAN-CENTRED	HUMAN-CENTRED
Features		
System optimises	Continuous improvement in work operation	Mix of social and technical sub-systems
Expected results	Systemic gains in quality and productivity	Increase worker commitment and targeted gains in productivity, quality and safety.
Role of workgroups	Problem and individual oriented	Task and group oriented
Role of buffers	Reduced to expose technical and organisational problems to press their quick solution	Augmented to decouple workgroup from other workgroups to allow self-regulation
Task interdependency between work units	Tightly coupled to internal customers and suppliers as well as to other workgroups; i.e. high task interdependency	Loosely coupled with other workgroups; i.e. low task interdependency
Task interdependency inside work unit	High	Lower or higher depending on work design of the group
Type of tasks involved	Only partially, some boundary transaction and conversion activities OR only partially some conversion and regulation activities	Regulation, conversion and boundary transaction activities
Extent of job rotation (including supervisory functions)	Low	High
Extent of decision-making	Limited decision-making activities related to self-regulation, self-governance and independence	Some decision making related to self-regulation, self-governance and independence
System constrains	Team autonomy and low labour/management support for continuous improvement	

Exhibit 4.3: Comparison between ideal types of HC workgroups and non-HC workgroups

Between work units. HC workgroups are 'loosely coupled' (Weick, 1976) along major customer or product lines¹⁰⁷. This organisational form places a premium on the exchangeability and expandability of subunits and on policies favouring a modular structure (Heydebrand, 1989:346). Thus, matrix type structures, for example, are used to combine functional areas (marketing, production, finance) into by product or by customer structure. It seems that this type of structure allows not only better co-ordination of different loosely coupled work units, but also contributes to their control and accountability. That is, matrix structures seem to be more efficient than other types in cases of high task uncertainty and complexity (Knight, 1977; Bartlett and Ghoshal, 1990). Additionally, these work structures enhance the 'organic' side of the organisation and lower the functional boundaries that exist between different work unit members (Hirschhorn and Gilmore, 1992). This favours experimentation and innovation.

HC Skills

Under the HC perspective, machines perform repetitive tasks and personnel cope with unexpected events to allow running of machines. Therefore, existence of an organisational structure that favours personnel skills formation and upgrading is a key instrument in achieving manufacturing system effectiveness (Mahlck, 1992). Since HC principles are based on a low (vertical and horizontal division of labour) entailing the reintegration of previously divided tasks and therefore an increase in the uncertainty and complexity of tasks, productive workers need to use tacit and formal knowledge (Erbe, 1992).

Higher personnel skills not only allow operators to cope with unexpected events, which means increased effectiveness¹⁰⁸, but also supports the improvement of work and job conditions. Higher skills, implies the firm's investment in training which, in turn motivates firms to

¹⁰⁷ Loose coupling is a dialectical concept that allows the simultaneous examination of rationality and indeterminateness to explain behaviour of industrial organisations. 'Loose coupling suggests that any location in an organisation (top, middle, or bottom) contains interdependent elements that vary in the number and strength of their interdependencies ... The fact that these elements are also subject to spontaneous changes and preserve some degree of interdependence and indeterminacy is captured by the modifying word loosely. The resulting image is a system that is simultaneously open and closed, indeterminate and rational, spontaneous and deliberate'. (Orton and Weick, 1990:204-5). That is, the loosely coupled concept recognises the possibility of simultaneous coupling and decoupling as well as emphasising the malleability of organisational structures through managerial intervention. This is a useful concept because it copes with complex and uncertain conditions (Weick, 1982), that are one of the key assumptions for the emergence of the HC model.

¹⁰⁸ Erber, Shaefer and Schoener (1989) noted that workers are capable of working with incomplete information if she/he has the idea (mental model) and can then imagine the production process. While this fact supports, but does not confirm, the technical superiority of the HC model, it is also congruent with Williamson's (1975) view that when transaction costs (eg scheduling, supervision, communication) are low, market-type structures emerge where these transactions remain externally dependent.

establish policies aimed at retaining personnel. In this way, the existence of high skill personnel together with active internal labour markets can promote the firm's efficiency (Williamson, 1975). Skills issues are also directly related to power relationships¹⁰⁹. Higher skills of personnel involves personnel empowerment (Wood, 1982; Lawler, 1990). However, the upgrading of personnel's skills seems to be enough to improve working conditions but not enough to seriously challenge management control. This is because the adoption of a particular skill strategy can clearly be a policy choice¹¹⁰ (Sorge and Hartman, 1983), made solely by management. Skills are thus upgraded as long as management power is not seriously challenged and workers deliver efficiency gains.

Some *new skill requirements* are: (i) Theoretical thinking. In addition to tacit knowledge, the worker must possess (formal) knowledge of materials, tools, products, the whole production process and structure of the computer-based information system, inventories, production planing, scheduling and tool management. (ii) Experimental thinking. The new worker's role is not only to produce but also to cope successfully with unexpected planning, product and process events (Toikka, 1990). To achieve this, the crucial importance of tacit knowledge and experience to perform work arranged along HC lines, has been widely recognised (cf Bohle and Milkan, 1988; Hedberg, 1990). (iii) Social qualifications. For instance motivation, co-operation, responsibility and communication abilities are all fundamental (Baudemer, Henning and Hilpert, 1990:44).

While the need for higher workers' skills to perform production and controlling activities has been acknowledged (cf Kopacek, Moritz and Stepan, 1990; Baudemer, Henning and Hilpert, 1990), there is no clear agreement about the amount and type of skills required for HC production systems nor about the necessary skill formation policies.

On the one hand, some commentators (cf Toikka, op cit) claim that these new skill requirements can be obtained from on-the-job training and do not necessarily require additional formal education. Wisner (1996), for example, suggested that in the case of low skilled workers, tacit knowledge is crucial for achieving high performance at work. This occurs however, only in situations where workers are involved in the design and management of work. This suggests that low skilled workers can have a high capacity of abstraction, and

¹⁰⁹ "Any academic discussion of job satisfaction, alienation or the effects of automation, which fails to describe the system of power by which capital defines and enforces the limits within which labour is compelled to operate, can be thrown straight in the waste paper basket" (Brighton Labour Process Group, 1977:16)

¹¹⁰ Technology by itself possesses potential capability to support, either upskilling or deskilling processes (Tuominen, Seppala and Koskinen, 1990; Forslin, 1990; Kirov, 1990)

this is what matters for workers to build by themselves functional representations of problems and how to solve them.

On the other hand, Ten Have (1990) found that production workers with different educational backgrounds qualify for the same job. This means that skills requirements are unrelated to job specifications. Due to the lack of knowledge about the amount and type of skills new manufacturing systems require, firms were asking for an educational level far superior than that required for the task. Only additional career training was necessary to learn the particular practices of the job¹¹¹. This finding makes sense as it seems to be that operative workers perform only a small fraction of 'creative' tasks¹¹². The impossibility of establishing a direct relationship between work and level of skill (Christis, 1988:79) further supports this argument.

HC Training

Training needs to be congruent with the firm's needs in terms of the type of skills needed. This causes three problems. First, as mentioned above, little is known about the type of skills needed for new types of jobs. Second, these new jobs are not in the majority representing only a small proportion of all industrial jobs. Third, while holistic approaches to training are regarded as positive, it is necessary to note that different levels of training are necessary for different levels of workers in the productive process.

Different types of training may be performed at different social institutions outside the firm. Some of these institutions, for example, are government funded, while others are funded by Industry and trade unions. The problem is one of establishing the appropriate co-ordination mechanisms to split these training tasks among existing and interested training and educational institutions. An additional problem to this is that the evaluation of the 'degree of qualification', is different from one country to the next since they possess different educational and vocational training systems and different management strategies. In one study, the German skills were identified as insufficient, while British research revealed managers were satisfied with skill levels¹¹³.

¹¹¹ Other research, (cf Manske, 1983) found that an NC operator does not need to upgrade his/her educational level to feed the machine with the parameters of the part. The utilisation of macros and GT techniques facilitates it in a significant way. Thus, there is no clear picture of the educational pre-requirements for a well functioning FMS.

¹¹² Martensson (1990) indicated that Swedish workers perform 15 % creative tasks (development of new solutions based on experience/knowledge), 40 % sensory-motoric activities (physical and motoric tasks) and 45 % perceptive-cognitive ones (ability to receive information, understand and deal with it).

¹¹³ Erbe, Shoefr and Schoener (1989) classified the qualification level in: (i) functional qualification (beginner, advanced beginner and competence); and (ii) innovative qualifications (agility and expertise). They

HC experiences show that an appropriate *training* approach is needed to support the 'complementary' approach of task allocation used in the human-machine interface issue (Gottschalch, 1986). That is, to provide training to prepare machine operators to cope with unexpected events and also to promote and improve his/her involvement in the surroundings of his/her own work unit. This seems to support the ideas of workers performing planning and controlling activities in addition to their direct transformation duties. Thus, it seems to be that some of the newly required skills (eg sensory-motor) can be learned through formal education, others (eg perceptive-cognitive) can be learned through on the job training and the remaining (eg creative) can be gained through experience.

4.5 IMPLEMENTATION AND CONFIGURATION OF HCMS

In order to be useful, HC design principles need to be 'configured' in a context. The implementation process is the terrain where principles are re-shaped and take final form. Moreover, the implementation process is an active process determining the nature and degree of human-centredness. Therefore, we need a more detailed understanding of the nature of HC configurations. This section therefore develops both technological and organisational HCMS configurations.

After the technology has been selected and bought and key organisational components have been designed, these (technological and organisational) components need to be implemented. During the implementation process, both technical and organisational components of manufacturing systems are re-shaped by the social actors involved in the accommodation of their goals/interests. In other words, technological artefacts such as software and hardware can be arranged during the implementation process in a wide range of configurations¹¹⁴.

The implementation process is a function of the social shaping of technological systems by user organisations, inter-organisational relations, and the broader societal context within

assert that the German qualification level is insufficient because German workforces possess insufficient 'innovative qualification'.

¹¹⁴ Because of its modular nature, CAD is a good example of technology that is configured during the implementation process. It consists of a language system (comparable to a very-high-level programming language) and with its aid the actual application functions can be assembled. These functions can be designed to meet the respective application needs. With each new function, the efficiency of the overall system and its adaptation to existing company structures increases. Such CAD systems are inherently capable of a very far-reaching adaptation of an existing work method and organisation (Schaffitzel and Kersten, 1985).

which these organisations are located (Badham, 1993: 5)¹¹⁵. The problem of implementation therefore, is directly related to how to design use of technology (and to whom). This entails the adaptation of technology, technology users and associated organisational factors to local conditions of operation.

According to Fleck (1988, 1994), the implementation process is both the mutual adaptation of technological components to the existing contingencies of the firm, and the innovation process itself. The innovative process results from the solutions of problems occurring during implementation.

During the implementation process, both technical and political rationality is used to 'customise and develop' the system. On the one hand, some writers, who use a soft-determinist approach, stress the importance of technological factors affecting social choices in the implementation process: "the technical characteristics and capabilities of a new system may be 'given' during the implementation process, acting as an independent influence both enabling and constraining the scope for subsequent choice and negotiation over issues such as work organisation and skills" (McLoughlin, 1992:6).

On the other hand, McLoughlin (1992) and Fleck (op cit), both assert that decisions made during implementation are also the result of political as well as technical rationality. One of the main reasons for this, is that, during the implementation process, the organisation of work is reshaped. This is associated not only with the technical efficiency of the system but also with socio-political issues (Webster, 1990). The established networks of power relationships would change and this is specially noted when technical managerial decisions are made.

"Not only are technical adjustments necessary (adapting, debugging, interfacing), but managerial and organisational adjustment requiring identification of choices, negotiations, decisions, justifications, planing, allocation of responsibilities and co-ordination between different groups and departments, are also necessary. In particular, the changes associated with the way in which human workers interact with the system are of crucial importance" (Fleck, 1988:46)

For example, system developers can make 'invisible' decisions to maintain their bargaining power but the user may not trust the integrity of the system developers' propositions (Bjerkness et al, 1988).

During the implementation process, organisational conditions such as existing skill structure, organisational procedures, organisational structure and formal and informal culture, are often more important than the technology itself in determining the final form of work and

¹¹⁵ The configurational nature of technology is the reason for the no existence of turn key advanced manufacturing systems (Ettlie, 1988).

organisational structures¹¹⁶ (Kelley, 1990; Forslin et al, 1989, Adler and Helleloid, 1987; Adler, 1989). Social factors seem to play a crucial role in the implementation process and are key elements in the success or failure of any organisational or technological reform¹¹⁷.

Knowledge of user requirements, local conditions of operation, non-automated practices and procedures, models of work organisation, assumptions about motivations, human skills, experience and tacit knowledge are the main elements of both technology and organisational configurations during the implementation process. Moreover, because of their loosely and ill-structured character, configuration technologies possess enough openness to be adapted to the current work reality, external situation pressures and internal local contingencies. Technological and non-technological contingencies are crystallised in the final work organisation form during the implementation process (Fleck, 1993).

Socio-institutional factors contribute to the reshaping of the final configuration of technology, organisation and users during the implementation process. Clark and Newell (1993) for, example, in their study of diffusion of production and inventory control systems, emphasise not only the extent to which technological artefacts (in this case a software package), reflect the prevailing contextual factors present in the design stage, but also the local features, such as supplier-user inter-action that might constrain or support the adaptation of foreign designed technologies to local conditions

The implementation process can be used not only to introduce new technology, but also the introduction of new technology can be used as an alibi to introduce organisational reform. That is, during implementation, besides customisation and development of the manufacturing system, a key task emerge: the achievement of organisational congruence (or fit) between resulting technological and organisational configuration and product/market strategies.

Two additional points need to be made regarding relations between the role of technological factors and the implementation process. First, during the implementation process, and almost independently from the orientation followed during the 'design of technology' process,

¹¹⁶ "Programmable automation (eg NCMT, FMS) alters the organisation of work in definite ways and changes the nature of tasks to be performed. But the resulting form of the organisation of work is not pre-determined by the technology nor by its trajectory... to a great extent, management's choice is constrained by economic, organisational and institutional forces" (Kelley, 1989:204)

¹¹⁷ A report of the Fraunhofer Institute for Manufacturing Engineering and Automation (IPK) for example, drawing on 10 year experiences in planning and implementing FMS concluded that "... therefore the most important factor determining success during FMS planning and development cannot be described by technological data or performances - experience with many planning procedures and successfully operation FMS customer's plants show that the key for success mainly lies in the attitude towards FMS of the people involved in planning, design, installation and operation"(Steinhilper, Storn and Reinhard, 1988:55).

technology might be applied in a wide range of forms, from technocentric to HC. On the one hand, the organisation of labour can be based on both vertical and horizontal division of labour, as well as highly differentiated hierarchical levels. Creative work is separated from routine work in order to allow managerial control of the process. This is because the level of output depends, to a great extent, on the pace of work. Bureaucratic control, such as computer and or human supervision, is used to control the pace of work with the aim of intensification.

On the other hand, in the HC approach to implementation, the deployment and integration of machines and equipment is based on socio-technical needs (ie technology is used to promote the operator's control over his/her immediate work environment). Besides production fluxes, plant layout, batch size and so forth, experience, qualifications and expertise of manpower are the key for machine efficiency (Schultz-Wild, 1990) and functional integration, which demands less clear cut boundaries between trades (Kopacek, 1989). These are key factors to be considered during the setting up of a manufacturing system. Depending on the level of qualifications available to the firm, the existing workforce will be grouped and combined in one way or another and will meet the functional requirements of the new technology to a greater or lesser extent. However, the above would be realised only as a product of a combination of technology with other factors such as market conditions, trade union organisation, managerial aims and government policies.

Second, manufacturing systems are rarely designed as customised systems. Rather, they are usually designed as 'generic features' of a system to be used in as many applications as possible. Manufacturing systems' developers and vendors usually offer standardised solutions that might be ill-suited to the unique needs of the individual firm (Badham, 1991). This is because two key features converge during the implementation process: (i) installation and commissioning, where customisation is a key activity; and (ii) post-commissioning in which development of the system is a crucial task (Voss, 1988).

When a technology is developed, its developer has made concrete assumptions concerning how and in which ideal situations that technology can be used. However, due to both the nature of those assumptions ('ideal conditions') and the 'transformation' that occurs to the technology during the implementation process, the final 'solution', (the technology installed and working under normal conditions), will usually differ from the initial expectations of both the developer and user of technology (Fleck, Webster and Williams, 1990). Technological system software, for example, is developed following the ideal type of firm and product. However, because of the diversity of situations existing in actual industrial firms - in terms of markets, types of products, competition, suppliers, machinery and internal human resources

practices - existing packages rarely match the firm's needs. Therefore, firms need to customise their software to meet their particular situation. Hence, '[the] adaptation, tweaking, mixing and matching of modules, wholesale rewriting of codes or even bespoke system specification have been the practices of almost every company' (Webster, 1990:12).

In a similar way, after the technological system has been customised, new requirements in processes/products or in ways of organising a firm's productive operations due to market or internal conditions, call for the continuous development of software and hardware solutions to meet current conditions. At the end of the implementation process, software will be 'reconfigured, rewritten, knotted together, amended and transformed to yield systems which represent unique technological solutions' (Webster, 1990:16). Therefore the development of the system is a continuous negotiation process in which different persons with different hierarchical levels and heterogeneous skills need to achieve consensus concerning each particular, cross-cutting, ill structured problem.

4.5.1 Technological And Organisational Aspects Of HC Configurations

Using concepts from information systems, organisational theory as well as from psychological views of work and organisation, this section outlines a model to configure the manufacturing system along HC principles.

Within the proposed framework¹¹⁸, the two key dimensions shaping the configuration are examined: (i) the technical; and (ii) the organisational. Each of these possess particular variables which contribute to defining the degree of human-centredness. The manufacturing system is qualified as HC if the degree of realisation in each one of the proposed variables ranges from medium to high¹¹⁹.

¹¹⁸ This framework is based on Corbett (1987, 1989); Corbett M., Rasmussen L., and Rauner F. (1991); Rowe (1989); Ahituv and Ronen (1985); Ahituv and Sadam (1985); McLoughlin (1990); Shney (1986); Kochan and Deutsch (1980) and Buchanan and Linowes (1980, 1980a).

¹¹⁹ As suggested in previous sections, each one of the items of a manufacturing system (ie, technical system, manufacturing system set up, organisational structure and allocation of functions) may change almost independently. Moreover, as is shown below, each component of each item may also vary independently from the others. This explains the wide range of organisational configurations that might exist. Additionally, it should be noted that in the configuration, a 'technical' component was incorporated. This is because technical integration of machines, equipment, production and information flows are an indivisible part of the configuration. This is also congruent with the soft-determinism argument used to conceptualise MES.

4.5.1.1 The technological Manufacturing Configurational Model

The technological manufacturing configuration model has decentralisation as a key feature. Decentralisation involves three sub-dimensions. Namely, geographical dispersion, processing power and linkage across machines.

The *degree of geographical dispersion*. This refers to the geographical location of the computerised equipment (hardware) related to design and manufacturing activities. Two general patterns can be identified. Namely, concentrated and de-concentrated. A concentrated pattern is when all computer-based manufacturing equipment is physically located in the same geographical area. A de-concentrated pattern occurs when work stations, data processing and peripheral equipment are dispersed equally in different physical locations. This physical layout supports, but does not determine, access to computed-based manufacturing equipment by a wide range of personnel.

The *degree of processing power*. This means the extent to which data processing is distributed and performed in a series of CPUs. Independence of those processing power points is highly desirable. The higher the degree of decentralisation, the higher the degree of human-centredness of this variable. An important point is that those machines must be linked.

The *degree of linkage across machines*. This is essential in achieving decentralisation in technical terms. Included in this variable is data storage distribution and equity conditions for data access. It means that all machines, hardware, software and peripheral equipment, must be linked and must be able to interact mutually. That is, they must be able to 'talk', interact mutually and interchange or share data. The assumption for this, is the existence of equally distributed accessibility to data-bases as well as equal access to information files. Different degrees of 'linkage across machines' are possible. An example of a low degree of linkage is when both hardware and software are linked among different machines but are unable to interchange information or when data flows in one specific direction only. The opposite case occurs when any machine (hardware, software) is able to interact with any other machine on equal terms. That is, information flows in a two-way pattern and machines possess similar privileges to access and manipulate files. The higher the degree of linkage among machines, the higher the degree of human-centredness.

Exhibit 4.4 provides a three-dimensional model of the technical dimension in HCMS. As has already been stated, these three variables are independent. Five typical cases are examined to illustrate this.

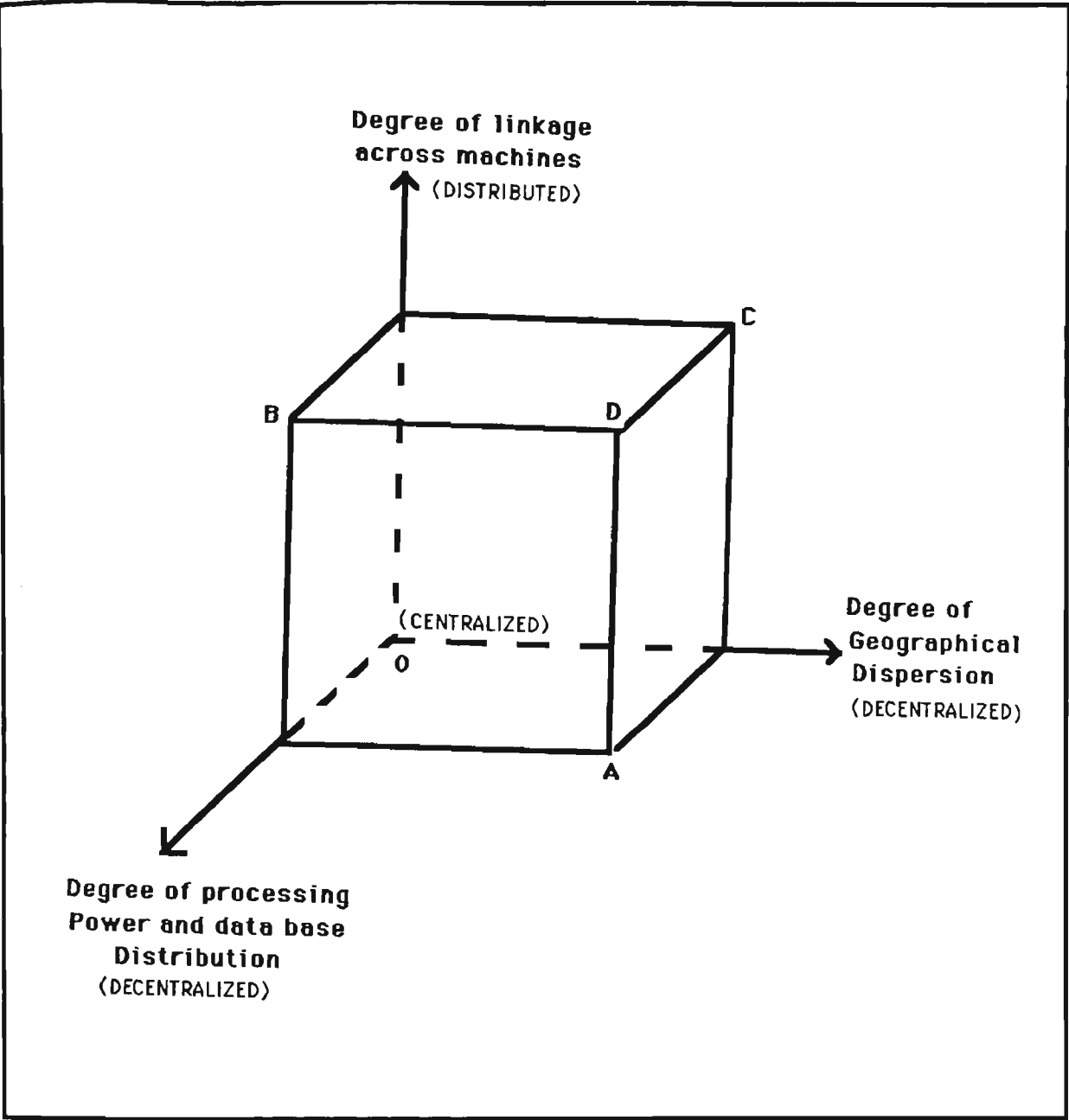


EXHIBIT 4.4: Technological Manufacturing Configuration Model

First, Point 'O' represents the most centralised case. At this point, the degree of geographical dispersion, data processing power and linkage across machines is minimal. A typical example could be the technical development characterised by one mainframe in which all data processing power and data storage occurs. Dumb terminals feed information to the mainframe which then processes the information following programs developed elsewhere. The output is transferred to high managerial levels without user knowledge. The information system management is developed and controlled by a data processing department without end-user support. Finally, end-users do not possess easy access to handle data and so perform a very limited role (only to feed information to 'The System').

This extreme case represents a 'mechanistic' approach of manufacturing system. In organisational terms, work and organisational structures are centralised and labour is vertically divided. The users are seen as 'formal clients' of the system and possess formal specifications on how to perform their work. As commented in previous sections, the success of this approach depends on the stability of all intervening factors such as data flow, data accuracy, materials and components, market demand and user actions.

Point 'B' represents an unusual case of a high degree of decentralisation in terms of both data processing power and linkage across machines with a low degree of geographical dispersion. For example, in a particular organisation, work stations can be linked and data processing power can be distributed amongst these work stations. However, all the equipment would be located in the same geographical area (unit or department). Although this example is an extreme case, it is not impossible to find such a technical configuration. This is because, 'technical' aspects do influence the final form of the configuration, but also the internal organisational political forces as well as external market forces also play an important part.

Point 'A' represents the case in which a high degree of decentralisation occurs in term of processing power and geographical dispersion. However, linkages across the machines do not exist.

The case in which a high degree of both geographical dispersion of work stations and linkage across machines, combined with low degree of decentralised data processing power is represented by point 'C'.

Point 'D' represents the extreme case of maximum decentralisation in the three technical variables. Namely, maximum geographical dispersion accompanied with a maximum decentralisation degree of data processing power and maximum linkage across machines. The difference between case 'D' and 'A' is that linkage across machines does not exist in the case of

'A'. It also represents the most decentralised point that the technical manufacturing system may take in order to allow organisational factors and users to be configured following HC principles. This does not imply that HC organisational factors are configured only if high decentralisation of the technical manufacturing system occurs.

The technical configuration of the manufacturing system does not only follow the technical rationale but also shapes and is shaped, by organisational factors and technology users at the same time. These organisational factors are examined below.

4.5.1.2 The Organisational Manufacturing Configurational Model

To be 'HC-oriented', the manufacturing activities need to be allocated along the following organisational principles. First, there should be a low level of vertical differentiation. That is, the production operations should include both manual and mental tasks as much as possible. This implies a low level of task division and a low level of functional specialisation. For this to occur, operators must possess enough skills and experience to perform different manufacturing tasks in addition to the execution of manual tasks.

Second, there should be a low level of horizontal differentiation. This implies that the division of labour among co-workers must be low. That is, they must be able to perform, as much as possible, all manufacturing activities required inside their work unit, including direct and indirect activities.

At the level of the work unit, the general principle is *minimum* management *interference* during work organisation set up. This means that management must limit itself to establishing broad goals (eg due dates, quality and quantity of output) and leave room to allow work unit operators to set up the timing of their activities, the work method, the work flow, and the synchronisation of manufacturing activities (Corbett, 1989)¹²⁰. A low level of pre-determination must exist, regarding when and how to perform manufacturing tasks.

A specific model for classifying HC organisational structures focuses on the degree of end-user control with special reference to three sub-dimensions: development, management and control, and operation of the system (see Exhibit 4.5). These represent the three main overlapping variables that are present during the whole life cycle of a manufacturing system (Ahituv and Sadam, 1985). The more the end-user controls each of one of these variables, the more the degree of human-centredness. Each key component can be examined independently and implemented to a higher or lesser degree. Therefore, points A, B, C, and D of Exhibit 4.5

¹²⁰

Note that these items further explain the concept of human-centredness presented in Chapter 1.

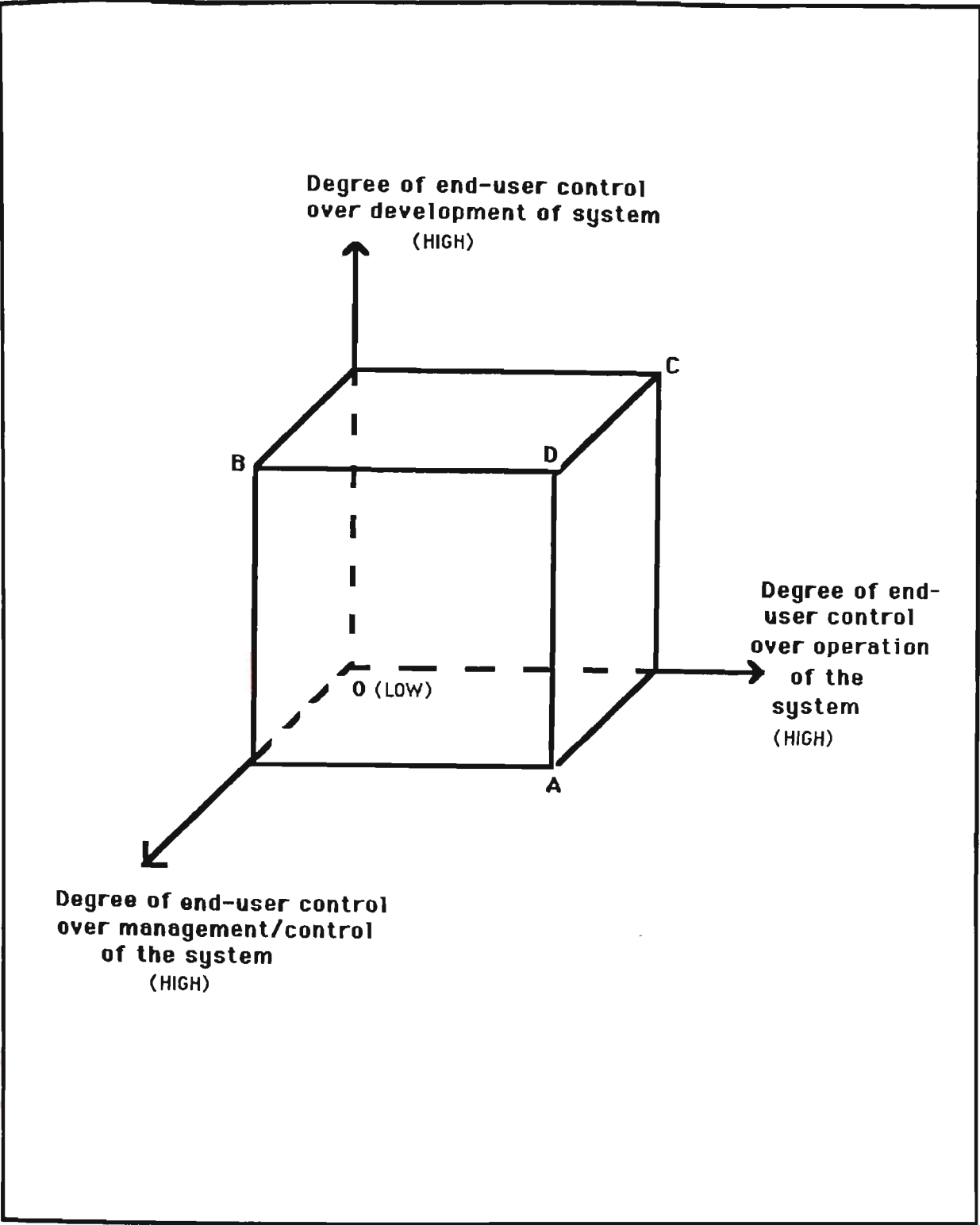


EXHIBIT 4.5: Organisational Manufacturing Configuration Model

represent a few of the combinations a manufacturing system can take in terms of who controls its set-up and operation.

The development of the system is a critical variable because the technical configuration of the system is set up during this stage. It is in this stage that trade-off between technical and organisational benefits/deficiencies occur. During this stage, social actors (ie managers, end-user, professional teams of information technologists) conduct negotiations. Thus, power relationships among those different groups, together with the existing technical limitations, define the final form of both the technical and organisational configuration.

This means closing some options of manufacturing system usage in favour of alternative options. However, this does not necessarily mean that the particular configuration reached after negotiations needs to be used in the way their creators thought. The inherent flexibility of computer-based manufacturing (or design) technology, in terms of different ways of utilisation, implies that the system can be used, implemented and managed in different forms even after it has already been developed.

Management of the system involves the outlining of procedures and working methods or, simply, the organisation of work. That is, decisions about how to divide and co-ordinate activities at work unit, department or project level are made. In the design sphere, for example, work organisation will influence, to a significant extent, the manner in which technology is used, the way designers, operators, drafters (or design) team members divide or split work. Put simply, management of the system involves who controls the way in which work and organisational structures are set up. As power relationships are not constant, the final work organisation will also be a dynamic process depending on technical, organisational and political rationality.

The resulting work organisation is, therefore, a function of technical constraints of the technical system, organisational structure and mainly, of resulting negotiation processes between key social actors intervening formally and informally in the set up of the manufacturing system. Social forces play an important role¹²¹. In the same way that it is possible to 'design' a manufacturing organisational configuration following a centralised approach, it is also possible to 'design' a HC manufacturing organisational configuration. Work organisation becomes a critical activity within the management and control variable. At the work unit level, high end-user control over management and control of operations is obtained

¹²¹ Zuboff (1989), for example, observed the 'evolutionary' nature of work organisation in computerised information systems workplaces, and Lee (1989) stressed the political nature of the decision-making process to adapt a centralised (or managerial control approach) or decentralised (or responsible autonomy approach) CAD/CAM system configuration.

when users control and manage timing and synchronisation of operations (Corbett M. et al, 1991).

Timing control refers to the timing of initiating, terminating and pausing manufacturing activities inside the work unit. Direct shopfloor personnel must possess control of the management of time available to achieve their goals. For this to occur, management must provide a reasonable length of time to allow room for manufacturing operators to perform not only manufacturing, but also co-ordination and problem solving activities.

Synchronisation of manufacturing operations inside the work unit refers to the level of operative integration which, in timing terms, occurs between different manufacturing tasks. When these activities have been minutely pre-planned to occur at the same time, a high level of synchronisation exists. The exact synchronisation of machine work that requires constant operator monitoring, does not allow the operator any time to perform other manufacturing activities such as planing, co-ordinating and problem-solving¹²². Lower levels of synchronisation, therefore, support loosely coupled relations between work units.

The HC model proposes a low level of synchronisation between operative tasks within and between work units. This implies the existence of optimal size buffer stocks between critical tasks and use of 'allocated time' (ie providing estimation of goals and due dates) instead of an imposed time approach. Delays or faults in one work unit would not interfere with normal operations in other units when a buffer exists. The same concept of synchronisation needs to be applied at inter work unit level. Activities between work units need to be planned in such a way to allow space and/or time fallibility in the work units.

The operation of the system. Operation activities must be performed and done so under the control of end-users in order to promote human-centredness. This variable has been separated from the previous one (management and control) due to its practical nature. That is, while management plans how to perform different activities, the operation of the system is the actual and real operation (usage) of the system. Moreover, all management planning and wishes will, not necessarily, be materialised when operations begin. The social relations, power positions, perceptions and intentions of individuals/groups involved, are crystallised together with the managerial plans and technical abilities of all personnel involved. Although the final form is not a static entity, 'operation' activities represent the final outcome of the particular manufacturing technological configuration. High degree of end-user control over work methods and workflow (Corbett M. et al, 1991) illustrate this point.

¹²² Coriat, (1988) called this "imposed time".

Work method predetermination must be low. Management must provide enough leeway for operators to reorganise, according to their judgement, their operating methods. This involves the use of technology which allows greater operator input as well as providing a range of operating alternatives to be chosen from.

Work flow refers to the flux of tasks (with or without use of machinery) that the part needs to take. A low degree of work flow pre-determination means that operators must be able to alter the work flow when necessary. This implies that PPC department planners must consider a minimum number of alternative work flows when planning operations. Additionally, to allow the set up of alternative work methods, the part must be designed in such a way that alternative forms of machining or assembly are possible. Therefore, machinery and auxiliary equipment must be as flexible as possible.

* * *

The position of a manufacturing system defined along these dimensions is the result of: (i) the preferred technological trajectory that the firm has opted for; and (ii) the negotiation processes (ie power struggle) between the key social actors involved. Both technical and political choices are negotiated jointly at each stage of design and implementation. The HC perspective supports user intervention at all stages of technological and organisational configuration as this allows not only technical efficiency (by stabilising technical, organisational and social 'turbulence'), but also supports better working conditions and may help to settle potential power struggles among the social actors.

It should also be noted that the use of HC criteria for designing HCMS is only one way of intervening in the shaping of the MES¹²³. By doing so, we seek to promote the achievement of technical efficiency in competitive terms and resource redistribution. This is a key pre-requisite in the promotion of labour market stabilisation in terms of better working conditions, rewards and training.

Theoretically, each variable in each dimension needs to possess a high degree of decentralisation (defined as an orderly dispersion or distribution of the different components in each sub-system), in order to possess a high degree of human-centredness. Individually, the above guidelines can be configured in different ways (ie anything from HC to technocentric ideals). Moreover, groups of those variables might be arranged into constellations of

¹²³ Other approaches were suggested in chapter 1 (footnote 25).

configurations. Therefore, following Mintzberg (1989), in the present study the emphasis is on how a set of attributes configure into types, rather than focusing on how individual variables arrange themselves along linear scales.

The presented HC model possess three strengths and one weakness. First, the proposed framework instrumentally conceptualises the decentralised manufacturing system. Traditional organisational concepts of decentralisation are very limited. They involve, for example, either separation/division into business units (cf Chandler, 1977), decentralisation as the contrary of centralisation (cf Brodie, 1967), or considering solely decentralisation of decision making (cf Sloan, 1965). The proposed view of decentralisation, outlines a multi-dimensional model that defines the degree of decentralisation of the overall socio-technical manufacturing system. Hence, it effectively considers technical and organisational factors jointly in defining decentralisation.

Second, exempting the manufacturing system set up dimension, the model can be applied at both the design and implementation stage. This is important because not only does it provide general guidelines for the design of work structures, but also by promoting active user intervention in the manufacturing set up stage, it builds a methodology for social actors to negotiate the set up of concrete work.

Three, the proposed model is multi-dimensional and each sub-dimension can be configured in a range of ways by social actors and external forces influencing firm level and technological choices. Because of this, it permits differentiation at each dimension, of the degrees of human-centredness and by default other approaches such as tayloristic (eg point 'O' in Exhibit 4.4) and neo-tayloristic (eg point 'C' in Exhibit 4.5). It is necessary to be clear that while the model does not contain all the elements involved in defining a manufacturing system, it does, provide a useful framework for intervention by management, worker and trade unions.

A weakness of the proposed model resides in the operationalisation (use) of the dimensions of the technical manufacturing system. It only points out different states of the technical manufacturing system in key sub-dimensions, but specific tools (eg indicators) are needed to measure these sub-dimensions in real organisations. The complexity of current technology, that allows the set up of an almost infinite number of technical configurations, further constrains the development of that tool.

4.6 THE PROCESS OF HC DESIGN AND IMPLEMENTATION

A key feature of HC organisational design and implementation is the participatory nature of the process. Traditionally, participation literature stresses involvement of employees but only at the operational level, or in the best cases, during the implementation stage. Participation in this case is limited, as key structural decisions have already been made. A British survey (Daniel, 1987), for example, pointed out that levels of consultation and negotiation over the introduction of technical change were low, including consultation of human resource personnel. The view developed here then, stresses the application of participation policies from the organisational design stage.

Participation, however, is a multi-dimensional and dynamic concept in which macro and micro factors shape participating practices. Contextual boundaries (eg society features)¹²⁴, values/assumptions and goals of implementators (firms and/or workers) and properties of participation (eg formal, informal, full, partial, direct, indirect), are all key factors in the shaping of participation issues at the firm level that might produce different outcomes for individuals, groups, organisations and society (Dacher and Wilper, 1978).

Depending on the approach to work and organisational structures (eg towards tayloristic-like or towards HC-like forms), a wide range of degrees and types of participation might exist. These different types of participation can be applied at different organisational levels¹²⁵. In

¹²⁴ The contextual nature of participation practices has been widely recognised. In the United States, for example, because of the general management/worker low trust level existing both at firm and macro level, the use of participative practices are limited. That is, they occur at a lower level. As a result, any positive results to the firm are negligible. Therefore the firm's competitiveness tends to be short-lived (Russel, 1988; Mahoney and Watson, 1993). Additionally, the way participative practices are used in the US seems to weaken trade union influence (Fantasia et al, 1988).

Conversely in Germany, where there exist a large pool of skilled labour, worker participation at higher organisational levels is supported by co-determination labour legislation. Additionally, strong power of bargain possess trade unions to assure worker's rights, plants are usually regulated by consensus, and interests of individuals/groups are taken into consideration. Therefore, work councils and management 'joint struggle for survival' assures that both firms and workers achieve common goals and some non-common goals (Hildebrandt, 1989).

In France, despite the existence of strong democratic traditions at the macro societal level, conservative thinking prevails around managerial ranks which produces an 'incomplete' participative approach. That is, some participative practices such as CCQ and teams are applied 'off-line', while the on-line retains tayloristic-like work practices and organisational structures (Linhart, 1992). This constrains any positive results for both workers and firms. As in the US, management/worker trust levels seem to be low.

¹²⁵ Pateman (1970) suggests that two types of participation are possible, at either a low or high level. In the case of low level participation, workers' input into decision-making is confined to daily shopfloor matters that maintain their subordinate role. In the case of high level participation, workers can influence strategic decisions that affect the whole enterprise (eg finance, marketing, industrial relations). For this to occur, power relations between workers and management must be balanced.

other words, participation can be configured in several ways, depending on firm level factors (eg workers and managers intentions, trust level) and macro level factors (eg labour legislation, trade union bargaining power and organisation, common forms of management/labour conflict resolution and stocks of skill existing in different economic sectors).

Experience shows that participating practices are important for the development of the HC concept. Because participation supports both manufacturing efficiency and better working conditions, it is a key feature of the HC view. Three important reasons support this argument. First, the use of participating practices brings improvements¹²⁶ in productivity. Second, the knowledge needed by workers about the production process can be better learned through the utilisation of participating practices (Levin, 1983). Third, participating practices can also be seen as a means of defending the collective interests of members because it permits their influence in the design of the work organisation (Flecker and Schienstock, op cit).

Because people, organisations and technical artefacts are configured by systems designers, implementators and users in such a way that their activities are performed within specific (technical and social power relationships) limits, it needs to be recognised that the current practice of participating approaches is rather limited. Current involvement practices for example, supports relative worker autonomy as they continue 'under' control. Inside the firm, computerised information systems, production control planning at macro level (long and medium term planning) and the possibility of computerised on-line/indirect supervision that technology offers, are the internal means available to management to control workers performance, material flows and outputs. Hildebrant (1989) called this 'the transparent factory'. Outside the firm, market pressures and the competitive position of the firm exert pressure over production workers (Pignon and Quertzola, 1974). Thus, the relative autonomy that production workers enjoy, as Brodner (1987) comments, "can only be developed within limits which leave management without fears of losing control over production" (p.110). It is in this way that 'autonomy and participating' practices must be understood within HC principles.

¹²⁶ Empirical research (Eaton and Voss, 1992) in the United States, showed, the different possible configurations that participating practices can take. Namely, configurations of work and organisational structures, reward systems and employee involvement that involve far reaching restructuring, were the ones that produced greatest productivity improvements. On the one hand, team production and gainsharing schemes, were the form that most enhanced productivity. On the other hand, employee stock ownership, profit-sharing and quality circles brought limited productivity increases. In Europe, Martensson (1989) noted that participating practices have been shown to be economically productive. In her study of FMS she observed that shop floor workers performed detailed planning and scheduling reducing administrative work. To achieve this, beside the adequate training supplied, personal micro-computers were provided for them to perform these activities.

Some practices that facilitate participation are:

(i) the existence of a low level of division of work; (ii) the use of a global participation approach (ie it must not be limited to one section or department); (iii) the allowance of enough time for workers to participate in outside direct production activities, such as learning formally or informally with colleagues, discussion with other departments, sections or teaching trainees¹²⁷. (iv) the existence of a balance of power between the negotiators (ie workers must have the power to influence the final decision-making and in the choice of alternatives¹²⁸; and (v) the existence of a high degree of trust between management and workers, seems to be a necessary condition for participation to occur¹²⁹ (Pekruhl, 1992; Fricke, op cit; Levin, op cit; Frei, 1983; Flecker and Schienstock, op cit).

Participation practices were successful in cases where the above pre-requirements were fulfilled to a significant extent. However there are important constraints to implementing participation practices. Some of these are: (i) the lack of trade union support regarding participation practices; (ii) the use of pseudo-participation practices as a managerial tool to increase pace of work only; and (iii) the prevailing values of middle management regarding the division of labour (eg the case when managers offer the possibility of participation to only a few privileged employees, generally highly skilled ones). The term 'worker involvement' probably better reflects current industrial reality. It might be understood within a four-dimensional matrix which includes (i) degree of involvement; (ii) type of involvement; (iii) hierarchical level at which individuals are involved; and (iv) the range of subject matter dealt with¹³⁰ (Marchington, 1992). Because each dimension is relatively independent, worker

¹²⁷ Informal participative commitment by the users of the technology during the design of the work organisation were more effective than formal changes. When the participating process is formalised, the changes that happened mainly reflected middle managers' views. That is, their method of coping with rationalisation issues, market goals set by their superiors and with technology characteristics.

¹²⁸ Because full participation at a high level might involve changes in capital/labour relationships - ie change the essence of the capitalistic labour process - full participation at higher levels is usually not found in firms. Participation at a high level, such as workers influencing re-deployment of work and organisational structures, occurs only if the workers possess enough influence on the choice of objectives and/or the selection of alternatives. For the latter to occur, it is necessary that the parties involved in the process, possess enough information and equal power to negotiate their arguments. In this way the balance of power between the parties involved is a key factor (Frickle, 1983; Levin, 1983; Flecker and Schienstock, 1989).

¹²⁹ Because participation implies in worker co-operation but collaboration is not 'free' (Tausky and Chelte, 1988) and because workers are not instrumentally oriented (Loscocco, 1989), a minimum of trust level between management and workers is needed to make participating practices work.

¹³⁰ Degree of involvement can range from simple information or communication to consultation, co-determination or joint management/employee control of decisions and actions. The most common form of involvement is found in the information to consultation bracket. There are different types of involvement. It can be direct (eg face-to-face communication or consultation); indirect (eg employee involvement through

involvement can occur in different ways. Different involvement practices can be applied selectively at different organisational levels. This makes the measurement of participating practices difficult.

A key feature of participation is commonly defined as the active intervention of the 'user' of technology¹³¹. Hales (1992) differentiated three types of user. The first type are those users who are seen as formal clients, to whom technology designers and implementators 'deliver', through formal specifications, the way to use the system. The second type are the users who are approached as co-designers. Transparent collaboration between users to-be, systems implementators and technology designers must exist. Thus, users are co-specifiers and co-evaluators of the way technology, organisation and social issues around the object of implementation are set up (cf Ehn, 1989). The third type of user are those approached as actors who are to be empowered, by enabling them to have full participation in the implementation process, thereby becoming (formal or informal) design constructors¹³². In Hales (op cit) words.

'You can present users with whatever 'props' (in the theoretical sense) you want, machines, artefact systems, data communications architectures, rule-systems translated into machine code; but how they act, through and around them is essentially indeterminate. Actors will act, according to their interpretations of the situation in which they find the system-artefact. Design of the artefact, before the fact, cannot fully design use... this user-actor view of design is inescapably political. Users 'construct' technology; they do this both symbolically, in their 'reading' of it and literally, in the articulation work that is essential before a concrete configuration of an artefact can serve as an adequate day-to-day supporting structure for a live practice' (p. 8).

User intervention under the HC approach, acknowledges user participation in the design of use processes. User participation means participation in negotiation processes that define/distribute/allocate roles and/or functions. As such, the role of management is to structure user activity by limiting and legitimising their activities in order to stabilise the mode of practice. Within this latter view, the following user involvement or oriented argument must be read.

representatives) and financial (when employee performance is linked to the firm's economic performance). Profit sharing and performance related incentive schemes are common in this latter group. Worker involvement might occur at different spheres of influence. It can be solely at task or section level, department or even at corporate level. Involvement is usually limited to task, section and departmental level. Finally, worker involvement might be related to very important decisions from financial and commercial matters to marginal issues such as parking access or quality of food served in the firm's canteen.

¹³¹ In the case of CAD/CAM technologies, due to their transcendent effects on organisation, ways of working, challenging social power networks and cross-cutting features, the role of users in the implementation process is vital. They are an important part of the system.

¹³² This third type of user is congruent with the constructivist view of user as well as with the configurational and processual view of organisations used in the present study.

Four reasons support the user-involvement argument. (i) immediate work activities are ultimately controlled by those who perform them; (ii) experts on operational factors such as task design are people who do the jobs; (iii) involvement acts as a motivation and will lead to more productivity and efficiency (Mumford, 1979:221-2); and (iv) user involvement is necessary because users are part of the system - it cannot function unless the people using the system accept the system (Clausen, 1979:232). Users need to be engaged at two levels.

Firstly, users need to understand the capabilities and limitations of the technology and how to use it correctly. For this task, user involvement in the customisation needs to be promoted in order to capture the real necessities in the particular applications.

Secondly, during the implementation process, the final technological configuration is defined. This will support or hinder the user's exchange of information. Hence, an understanding of both the organisational task and the relationships between and among different levels of users, is necessary in order to develop the informal social network that is installed in parallel with electronic technology (Damora, 1986).

Different user-oriented implementation strategies were observed in the literature (Ives and Olsen, 1984; Mumford, 1977; Friedman and Cornford, 1987; Szyperski and Grochla, op cit). First, full user involvement occurs when both the user and the system developer define and realise the development of the system. This includes technical and organisational routines, procedures and practices. Unfortunately, due to communication and qualification problems, this alternative has not been much used¹³³. Second, in the consultative case, users possess sign-off power in each stage of the system development process. Third, in the representative case, users appoint representatives to actively participate in the development of the system. Such representatives need to possess enough knowledge and experience in both organisational and technical matters. The two above models can be performed in three different ways: (i) both users and system developers define and realise the proposed changes; (ii) users (or their representatives) define the problem and both users and system developers realise it; and (iii) system developers define the problem and both user and system developers realise it.

¹³³ During the implementation of CAD technology, for example, one main problem is that users are, usually, not able to articulate the problem to be processed precisely (from the developer's viewpoint). The user, who thinks and behaves in his/her specialised language and lives his/her specialised work reality, lacks specific knowledge concerning the operating mode of CAD technology. The system developer by contrast, sees his/her task as converting the specialised problem of different users into an algorithmizable structure, transferable to a data processing system. He/she depends on the specialised knowledge of the user but must apply it at a higher level of abstraction (Schaffitzel and Kersten, op cit).

It is noteworthy that the implementation process approached under the constructivist view of users, is congruent with three features of the HC concept: (i) it recognises, and allows room for management/users negotiation processes of conflicting views; (ii) it fits the configurational view of users; and (iii) it is congruent with the empowerment implied by HC participation practices.

4.7 CONCLUSION: STRATEGIC CONGRUENCE BETWEEN TECHNOLOGICAL, ORGANISATIONAL AND PRODUCT/MARKET CONFIGURATIONS

Finally the alignment of key strategic dimensions is a key feature of the HCMS. Far from new, the 'fit' question is a well known concept in organisational theory (cf Katz and Kahn, 1966; Lawrence and Lorsch, 1967). This concept is incorporated into the HC model because the sole adoption of HC principles without consideration of the congruence of strategic dimensions with its environment, brings limited results (Khandwalla, 1973 cited by Child, 1984; Mintzberg, 1981). HC guidelines call for congruence at two levels. Internally, among organisational components and externally between organisational components and their environment.

During the implementation process contingencies of a technological, organisational and social nature are (re)shaped by technology implementators (ie management and/or users) in such a way as to match the organisational setting at firm and work unit level. This can occur in two, not mutually exclusive ways. First, product/market factors and technological and organisational configurations need to be reorganised so that they match work demands at work unit level (eg at the manufacturing setting). Second, work demand at the manufacturing setting can be changed to accommodate the above three dimensions. Hence, the key of the implementation process is the ability to adapt and match product/market factors (ie business strategy), technological and organisational configurations. Theoretically, a successful implementation is one in which design and manufacturing profiles, technological and organisational configurations are congruently set up.

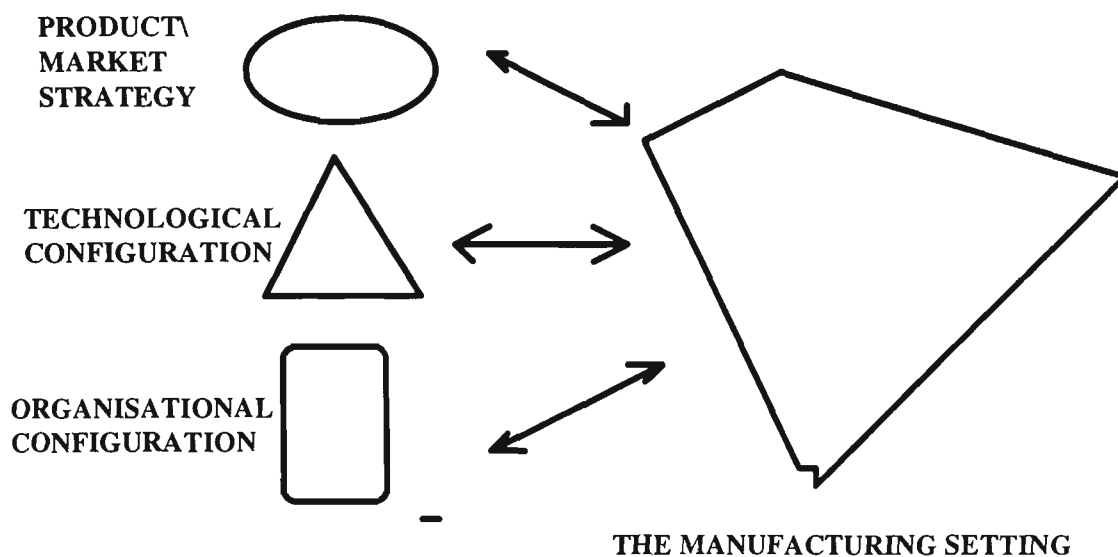
The adaptation process that occurs when technology is implemented is crucial because a technology very rarely fits perfectly into the user environment. This misalignment can be corrected by alteration of the technology or a change in the organisational environment. However, to change both the technology and user environment is more beneficial than a change in only one of them (Leonard-Barton, 1988).

Exhibit 4.6 (a) illustrates the relationships between contingencies, technological, social and organisational pressures and the organisational setting. In this situation, all the elements need to be re-shaped to be congruent with others. Exhibit 4.6 (b) shows the organisational changes that are necessary to perform a 'successful' reform. They can be separated into three general steps.

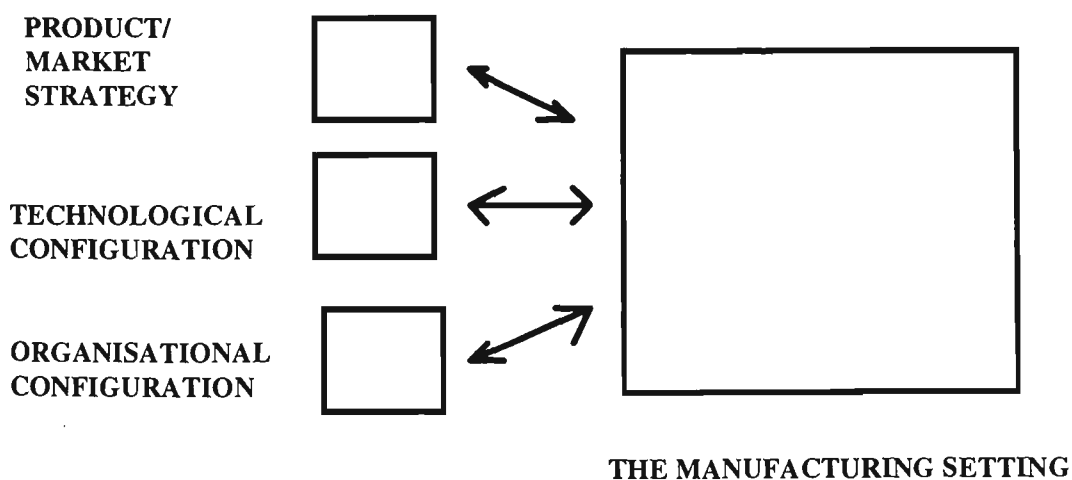
Step 1. By correctly choosing the target market, management shapes the firm's design and manufacturing profiles. By selecting the appropriate technology available and planning the implementation process, management can handle technological pressures. By determining the appropriate human resources policies and organisational design, management can re-direct organisational issues.

Step 2. The given human resource practices combined with the current work organisation are framed by the organisational structure. As skills, training, career patterns, selection and wage system policies are all framed by the organisational structure, these dimensions need to be congruent among themselves. Within the social/organisational factors, the assessment of the way the introduction of new technology would challenge the existing network of social power relationships is an important task to be considered in the planning of the implementation process. This is also, in most cases, a managerial prerogative. In organisational terms, this implies obtaining a relative equilibrium between the level of integration achieved to co-ordinate, the different types of work performed between and inside design and manufacturing spheres.

Step 3. The two former steps must be matched. This process is the principal task of the organisational reform. Depending on the degree of fit of the above organisational dimensions, the organisation will possess a higher or lower organisational integration among its key organisational components. On the one hand, the more congruent the organisational dimensions are, the more integrated the different work units of the organisational structure will be and the use of participating strategies to customise the system will be more successful. However, it seems that changes in the formal organisational structure alone such as the matrix structures, do not guarantee the desired organisational integration unless they are complemented by user-oriented strategies. In fact, both strategies must be seen as complementary integrative mechanisms and not simply as an implementation 'tactic'. User-oriented strategies of implementation need to be accompanied by an adequate managerial strategy such as responsible autonomy concerning the workforce (Friedman and Cornford, 1987). On the other hand, the greater the dissonance between the existing organisation and the



(A) BEFORE IMPLEMENTATION



(B) AFTER IMPLEMENTATION

EXHIBIT 4.6: STRATEGIC CONGRUENCE BETWEEN TECHNOLOGICAL ORGANISATIONAL AND PRODUCT/MARKET CONFIGURATIONS

proposed system, the greater the need for implementation tactics based on power and politics¹³⁴.

In consequence, it is suggested that technological and organisational innovation must occur simultaneously. Indeed, neither the organisational nor technological shift is automatic: they need to be planned, managed and implemented by people. Therefore, the crucial point for obtaining congruence lies in the opportunity that the implementation process brings to introduce, not only the technology, but also the necessary organisational changes, which may represent a change in the whole culture of the organisation. As Majchrzak (1988) remarked:

[...] in planning for new technology, remember that the human infrastructure must be constructed in such a way that its important elements are congruent with each other. Otherwise, both the technology and the human resource opportunities are wasted ... [congruence] is the complete configuration of interrelated changes and decisions that determines whether the system will fulfil the promise of advance manufacturing technology ... configurations of each element of the human and technical infrastructure are virtually infinite in their variety. Any of them can be successful as long as the elements are matched. A highly bureaucratic manufacturing organisation can be as successful as a team-based organisation, provided it has matched elements (p.297).

The foregoing chapter has considered, theoretically, the design and implementation of HCMS. The next chapter considers Brazilian macro conditions, underscoring the complex contextual factors that may influence the actual adaptation of HC principles.

¹³⁴ For details regarding the organisational political dimension of the implementation process see specially Markus (1981), Peters (1978) and Danzinger et al (1982).

CHAPTER 5

HC CONCEPTS: A MACRO LEVEL VIEW

5.1 THEORETICAL FRAMEWORK

An important variation of the HC approach is the inclusion of macro institutional forces that to a greater or lesser extent provide, but do not determine, the conditions that affect the nature and introduction of alternative production models such as the HC view¹³⁵. This is an important component of the present study because the implementation of HC principles considers adaptation to local conditions. In this case, the empirical base is a semi-peripheral nation where macro institutional conditions are different from the ones existing in European industrialised nations, from which the HC view is being developed.

Explanations based on the analysis of firm level factors, are not enough in themselves to fully understand and explain the industrial practices. Managerial hierarchies, workers' views and firm products/processes strategies, only partially explain how manufacturing operations are performed and the associated outcomes, such as productivity. Comparative studies on manufacturing practices (cf Cole, 1989; Bessant and Grunt, 1985) which have used alternative approaches, have seen the need to look for explanations at national and regional levels which, in one way or another, influence how manufacturing operations are configured at firm level¹³⁶. To ignore or minimise macro/meso factors then, is to weaken the analysis of manufacturing practices¹³⁷.

¹³⁵ It should be noted that the inclusion of the 'macro' view is important as it addresses a key theme overlooked by Brodner (1987).

¹³⁶ National institutions possess an overwhelming importance for development, or as North (1990) put it, "... institutions determine the performance of economies" (1990:37).

¹³⁷ Cole's (1989) comparison of small-group activities in American, Japanese and Swedish settings is specially relevant. He pointed out the different roads these nations have taken to promote small-group activities in industry. He noted particularly that, besides the firm level factors, institutional and social actors were the key shapers of the social institutions which promoted small-group activities. In Cole's words,

"Generally speaking, the answer is to be found in a confluence of factors, ranging from different labour-market circumstances, labour-management traditions, and the predisposition of major institutional actors (especially the degree of top management consensus) to the willingness of those institutional actors to take joint action to build national infrastructures for diffusion small-group activities" (p.14).

It can be seen therefore, that the analysis of both macro national and international institutional forces is crucial to the understanding of how macro structures have emerged and are linked with meso and micro (firm level) factors (Nelson, 1993, Marceau, 1992). Three reasons justify this macro approach. First, while there are few doubts that important changes in world industrialisation patterns are occurring¹³⁸, the nature and sources of those changes remain controversial. The assumption that a new techno economic paradigm (Perez, 1983, 1988) is beginning, has been seriously challenged¹³⁹. Second, it is a problematic assumption that the type and quality of the changes occurring in industrialised nations will be directly reflected in semi-peripheral nations as outcomes of possible changes are different for different nations. Third, very little is known about the increasing market uncertainties at firm level and their impacts on semi-peripheral nations. All these arguments indicate the need to study national macro conditions where the HC model is implemented.

The present macro level examination integrates three complementary theoretical views. The National Systems of Innovation (NSI) approach (Nelson and Rosenberg, 1993; Lundvall, 1992; Anderson and Lundvall, 1988); the institutionalism view (North, 1990; Streeck, 1992) and; the industrial culture ideas (Rauner and Ruth, 1990). The framework presented (see

¹³⁸ Storper (1990) detailed the new conditions that globalisation brings to the industrial organisation: "1) high levels of market inter-penetration create higher levels of risk for producers, since markets can be more easily contested; 2) production flexibility is both a response to such risk and its stimulus, since flexibility makes possible more frequent product changeovers - and therefore encourages still further market contestation; 3) flexibility makes possible the production of less standardized goods, but these in turn are oriented toward narrower market niches, thus *ceteris paribus*, reducing the scale of production that can be supported in any one firm, country or region. Yet the 'background' investment in equipment, product planning, and marketing are, if anything, greater than ever; specially in technology intensive production processes or design-intensive products; and 4) these investments require amortization either over a large quantity of output of one good or over a range of differentiated goods" (p. 432)

¹³⁹ Two important criticisms have been made. *Firstly*, even though it must be admitted that we might be at an 'important turning point' in the evolution of capitalism, it is still too early to qualify the nature, or rather its sources and composition, of macro changes (Chandler, 1990). For Chandler (op cit), causes are unknown and generalisations can not be made: "The Institution's post-War history has only begun to be studied. Its history after the intensified competition of the 1960s and 1970s is even more vaguely understood. The events are too close; the interrelationships between the institutions and its environment are too complex; and the data needed for description and analysis have still to be collected. Valid description and analysis on which generalisations can be made must wait an in-depth , industry-by-industry, country-by-country historical study..." (p. 621-8).

Secondly, by treating firms/groups of workers/national economies as 'units' to which outside forces (eg technology and markets) press in particular directions, neo-Schumpeterian theorist are, instead of informing, fitting historical developments into rigid theoretical schemes (Elam, 1990:33). In this sense, by arguing that we are in the post-Fordist era, scientists and academics seek to create a social reality to favour its materialisation. "Science plays the role of legitimator and validator of established practice; a practice which may continue for long periods even when on many criteria the technologies themselves are manifestly not working" (Clark, 1987:37).

Exhibit 5.1) considers both internal (ie domestic) and external (ie global) forces that converge to determine the competitiveness of a nation. These factors influence, either positively or negatively, the adaptation of HC principles at firm level.

This approach is useful in two ways. On the one hand, it connects a particular national infrastructure to the internationalisation of the economy; and, on the other, to aid examining national configuration of capabilities to set up and diffuse institutions/mechanisms/rules, which must be tailored to the nation's current infrastructure.

Externally, market orientation, access to state-of-the-art technology, trade agreements, and TNCs behaviour are the important factors that influence a nation's industrial performance. Each of these factors might support or constrain, directly or indirectly the introduction and diffusion of HC concepts, at firm level. These factors are considered external to the national environment due to their dependency on supra national events rather than on intra-national decisions. This is truer in the case of developing countries, where national laws and law enforcement institutions are weakly organised.

1. *Market*. Theoretically, world markets are the largest and the most profitable. Any nation willing to pursue a sustained development strategy should target these. However, while they might be the most profitable, they are not the only target available. There are also alternative markets which are being neglected by semi-peripheral economies such as southern, regional and even domestic markets. Moreover, the degree of contest in these markets is not only lower than in central nations markets but they also possess significant potential and are currently under-estimated by both central and peripheral nations. However, technology access, trade agreements and TNCs behaviour are other important factors that favour or constrain a nation's ability to reach the desired markets.
2. *Accessibility to state-of-the-art technology*. Access to high technology is problematic to semi-peripheral nations. For example, increasing difficulties are found in reaching those state-of-the-art technologies because 'only local' formal or tacit rules are applied in OECD research programs and US/Japan consortiums (Ernst and O'connor, 1989).
3. *Trade agreements* refer to the political arrangement made by groups of nations in order to increase trade flux. This means that foreign direct investment (FDI) and trade flux, with its associate technology transfer capability, are increasing. Thus, it is possible to state that the world economy is more interdependent than in the past. However, it is necessary to note that tight interdependency amongst nations occurs more in advanced nations than in developing countries. This is due to FDI investments and trade fluxes being incremented

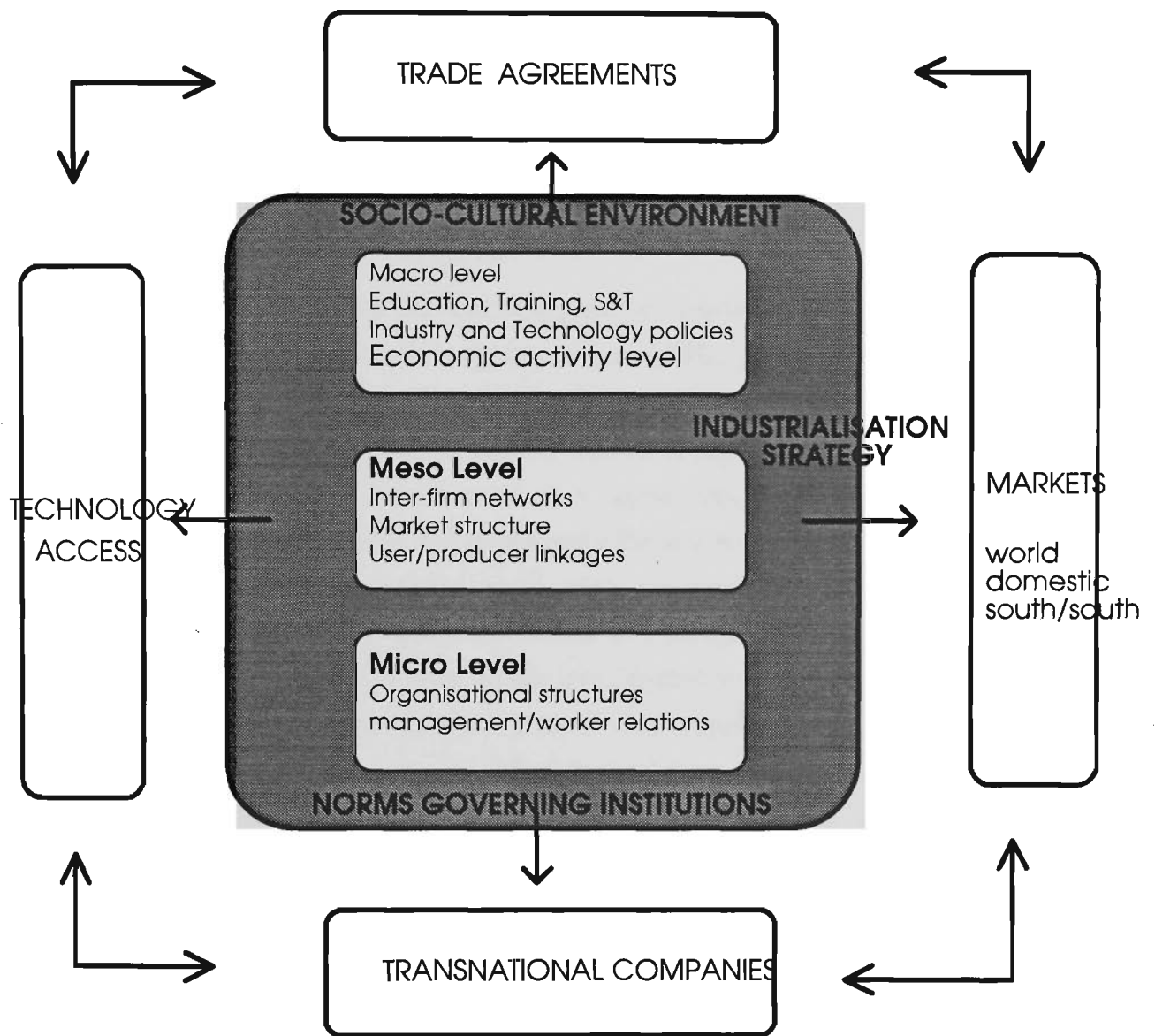


EXHIBIT 5.1: HC CONCEPTS: THE MACRO CONTEXTUAL VIEW

more in advanced nations than in developing countries¹⁴⁰. Some commentators (cf Hirst and Thompson, 1993), have suggested that, because the structure and distribution of power in the international economy is determined by the major nation states, world trade is organised in such a way as to continue promoting and further strengthening the economies of advanced nations. Non-tariff barriers for example, are each time increasing against NICs. Because of balance of payments problems and increasing indebtedness, the US is exerting pressure to constrain market penetration from Japan and NICs (Ernst and O'connor, 1988).

4. *TNC* are in the midst of the process of the internationalisation of economy. This is one key factor which can influence the implementation of HC approaches. The TNCs role is important for the industrial development of any nation as they enable the transfer of technology, make possible the re-location of industrial facilities and might set up crucial strategic alliances¹⁴¹. TNCs, constituted as a supra national entity, might support or constrain industrial development and particularly the implementation of HC principles. By introducing innovative technologies, production processes or products, for example, TNCs might contribute to the diffusing of this knowledge by hiring local people. This, however, is not always true. Contrary to the less developed European economies, the role of TNCs in Brazil has been marginal in terms of their contribution to the development of indigenous technological capability (ie skills/knowledge by doing research locally). Due to the TNC's tendency to locate their most value-added R&D activities at their headquarters, SOE (State Owned Enterprises) have performed that role in Brazil since the 1970s. While this strategy is not feasible at present, it did create a solid stock of knowledge in different industrial sectors such as the petrochemical, nuclear, aeronautic, automobile and civil construction areas.

¹⁴⁰ In reality trade fluxes, technology transfer and TNC mobility are increasing but only within advanced nations. North/South technology transfer has been stagnant since the 1980s. World trade figures also indicate an increase in trade but only amongst advanced nations. In 1967 for example, 75 % of world trade occurred among OECD countries. In 1985, that figure increased to 80 %. World FDI inflows show that between 1985 - 1989 FDI influx to developing countries has decreased from 25 to 19 %; only 0.1 % of world FDI has flowed to least developed nations (OECD, 1992).

¹⁴¹ Strategic alliances in core technologies are all confined to highly industrialised nations TNCs. In 1987 for example, the 10 top computer firms controlled 90 % of world markets; in the case of the telecommunications industry that figure is 85 %; in the case of the semi-conductor industry, top 10 firm controls 61 % of world markets. The top 10 TNCs in technology-intensive industries are all located in advanced nations (OECD, op cit).

Internally, key national institutions¹⁴² (North, op cit, Rauner and Ruth, op cit; Nelson and Rosenberg, op cit; Anderson and Lundvall, op cit; Bandemer, Hennings and Hilbert, 1991; Wobbe, 1991; Lehner, op cit) are differentiated at 3 levels¹⁴³.

1. *At the firm level*, national patterns of organisational structures, integration of manufacturing technologies, capital/labour relations, work organisation forms, prevalent types of organisational structure and management practices, all influence a nation's industrial development and a firm's supporting or constraining conditions to implement HC principles. In reality however, it is difficult to find only one particular practice. What really exists is a high heterogeneity of production regimes depending, among other factors, on the industrial sector, market target and geographical area. More importantly, significant differences in production regimes between different nations exist (Boyer, 1989; Turner

¹⁴² Institutions can be conceptualised as historical, political, cultural and social entities which "impose and enforce social obligation that rational individuals would not voluntarily and contractually take upon themselves" (Streeck, 1992:37). Institutions can be defined as the 'rules of the game' in a society. That is, institutions are socially determined devices which constrain human interaction. These rules influence the way institutions emerge, evolve and act (North, 1990:3-10).

Streeck (1992) further elaborated on social institutions which shape the 'supply' side of advanced economies. In short, he stresses the crucial existence and positive performance of institutions to fully allocate productive factors in order to complement market and management hierarchies forces. He also sees a direct connection between industrial output and social institutions which harness the views and actions of the social actors. More importantly, he links firm level productive practices and meso level institutions with existing institutional (macro) arrangements,

'Institutionalised constraints and opportunities operate as a chain of interdependent micro-level decisions- on product ranges, production technology, work organisation, skill formation and wage differentials - that link product markets to the social system of production' (p.29)

The study of institutions - institutionalism - can be approached through several disciplines such as economics, sociology and organisational theory and, at different levels : sectoral, inter-organisational and organisational (Powell and DiMaggio, 1991). Best (1990), for example, after analysing micro and macro institutional factors both in Japan and Italy, proposed a four component model of 'new competition': organisation of the firm, types of co-ordination across phases in the production chain, organisation of the sector and patterns of industrial policy. For the purposes of institutions which shape national systems of innovation, national institutions are analysed from the sectoral level, considering economic and social aspects of those institutions.

The idea of the important role played by key national institutions is not new. Earlier research, for example Landes' (1969) historical study of the industrialisation process in Western Europe, found what has now been verified through empirical cross-national research. This is, that the broader political economy, the 'dominant' ideology, national politics, national educational and training systems, external economies of proximity in inter-dependence (ie cluster or networks of firms) and the industrial relations environment as well as the degree, quality and direction of government intervention, all contribute to the forming of national conditions that favour or hinder different economic sectors in a nation.

¹⁴³ The three latter authors evaluated the feasibility of implementing HC manufacturing systems in the European community, within the FAST research program. Other empirical based research has confirmed the importance of the mentioned factors at micro, meso and macro level. See for example, Lane (1989); Bessant and Grunt (1985); OTA (1990); Haywood (1992); Bessant and Rush (1993); Kelley and Brooks (1991); Brunner (1991); Orru, Biggart and Hamilton (1991), Berger et al (1991).

and Auer, op cit) because the institutions and social actors shaping their productive systems possess different roles, importance and powers of decision-making.

Managerial hierarchies for example, are seen as a key factor in influencing industrial competence. However, different types of managerial hierarchies exist. While different types of hierarchical behaviour would influence different competitive outcomes, it is only where managers inspire members of the firm to transcend short-term self-interest that they will hold a competitive advantage (Miller, 1992). The latter type of hierarchy constitutes a key HC supporting factor. Thus, it is necessary to examine the extent to which national socio-political institutions favour or hinder this type of managerial hierarchy.

2. *At the meso level* (eg regional), inter-firms networks, industry/government bridging institutions, market structure and user-producer linkages are all related to a nation's industrial competitiveness and firm conditions to implement HC principles (Porter, 1990; Nelson and Rosenberg, op cit).
3. *At the macro level*, educational and vocational training systems, S&T infrastructure, industry and technology policies, capital/labour environment, legislation and co-ordination government bodies, as well as political constraints are all factors which are permeated by the national norms governing these institutions, the industrialisation strategy adopted and the wider socio-cultural environment. Firm level factors affect and are affected by meso and macro level conditions. The workforce skill level includes the current supply of skilled manpower, training practices, wage allocation structures and participation practices used at shopfloor level. This is a function of the demographic rate, the industry absorption rate of skilled manpower, the existing capacity of vocational training at both private and state institutions as well as of the general educational system.

The technological infrastructure available nationally involves software, hardware, technical assistance and the availability of technical/organisational knowledge (eg consultancy firms diffusion state-of-the-art organisational tools).

The wider industrial relations environment involves not only employers' and employees' associations and current legislation, but also the power which those social actors possess with which to settle their differences. An important constituent of the industrial relation environment is the implicit attitude of social actors towards conflict regulation. In other words, the quality of that relation, ie conflicting or co-operative in extremes cases, is another crucial element in the wider industrial relation environment.

The research and Development in Science and Technology government policies. In the case of highly industrialised European nations, this means, a priori, the existence of enough financial resources to invest in a research policy, the setting-up and organisation of government agencies whose first goal is to promote and link government funded basic research to privately funded industrial applications to carry out S & T activities. Secondly, the availability of financial resources for investment in basic and applied research. It is important to note also, that in industrialised nations, privately-funded basic and applied research is significant.

Above micro, meso and macro level, national institutions are interrelated within a common ground of tacit, formal and informal rules, norms, costumes and values (North, op cit; Rauner and Ruth, op cit). Four seem to be important. First, the wider industrialisation strategy, Roughly speaking, it can be from inward to outward oriented, mass low cost/quality markets or customised high quality/cost markets. While nations often possess more or less formalised 'industrialisation strategy', the operationalisation of that strategy implies in interpretation of that general guideline.

Second, the current economic level of development. Depending on its stage of economic development, a nation might or might not have favourable conditions to introduce and diffuse HC strategies in terms of (i) the recognition of human skills and consideration of non-technical approaches to set up policies and mechanisms supporting HC introduction at firm level; (ii) the existence of R & D programs which might contribute to adapt imported technology and organisational concepts to national conditions; and (iii) the level and extent of debate, at national level, regarding the need to boost the industrialisation process along with social equity. That is, besides adopting strategies to solve market related industrial issues to improve working conditions and promote income homogenisation.

Third, the wider socio-cultural environment. That is, the larger population's ways of thinking, behaving and acting. For example, the existence of craft skills and unusual modes of operation which do not exist in advanced nations are not counted in official statistics. National traditions embedded in the socio-cultural environment seem to be specially important. They include implicit and explicit social consent arrangements about the collective meaning of work and, more importantly, the stock of cultural values that are reflected in the way technology is developed and applied. Social and individual psychological factors are also included in this category. They encompass national socialisation forms, such as the different cultural patterns constituting subjectivity and the importance of individuality within the individual/society relationship.

Four, norms that formally or informally govern institutions. These norms are usually non-written patterns of thinking and action that different groups of social actors possess. The 'political constraint' factor is an example of the latter. Because of the usually immature stage of democracy achieved in developing nations, political constraints (derived from historical traditions) entrenched characteristics of the political system, social structure determinants and formal properties of political institutions (Whitehead, 1990:1133) - interact with formal industry, technology, training and educational policies. Thus, it is necessary to consider those existing political constraints when analysing the institutional factors in the national system of innovation.

Other factors such as technology usage, the existing imperfect market conditions, and the preferred path of managerial hierarchies, all respond to formal and informal (tacit) institutionalised rules at inter-organisational and level firm. The socio-political examination of the key national institutional forms which shape macro economic activity, (Granovetter, 1992) would eventually contribute to the further clarification of industrial behaviour in the Brazilian setting¹⁴⁴. All these institutions and mechanisms may prevent or promote and diffuse knowledge creation and knowledge improvement, depending on how they are organised and funded.

The above mentioned institutions are at the core of any nation's industrialisation process. Nevertheless, it is necessary to note that, in different nations, these institutions perform differently as they are organised in a myriad of ways. They are supported by different social actors, and might possess different goals. In industrialised nations, these institutions are not only recognised as crucial in their role but also, their governmental policies reflect that importance. Hence, substantial investment and organisational efforts exist in order to maintain industrial leadership through the manufacturing of technology-intensive products.

¹⁴⁴ In the search for relations between micro and macro factors, however, it is necessary to recognise that little in-depth understanding of relations between micro and macro structural relations. Therefore, rather than search for cause-effect relationships, ie are macro factors a cause and micro factors effects and vice versa and which one is more important, it is necessary to observe how they are connected in order to understand the changes occurring at micro, intermediate and macro levels. This will permit an understanding of the dynamics of this process. That is, how one level of analysis might shape other levels and vice-versa. At this stage it is safe to assert that dynamic relationships between macro and micro factors shape competitiveness levels both at the national and firm level.

However, there is little agreement among sociologist regarding the importance degree of micro and macro categories. On the one side, Collins (1981) for example, has pointed out that macrostructures are aggregates of microsituations. On the other side, Blau (1987) for example sees (macro) structural conditions as limiting options and influencing inter-groups relations.

Conversely, in semi-peripheral nations, government policies do not necessarily reflect that importance. It is not unusual to find among semi-peripheral nations, for example, weak educational and vocational training institutions as well as a lack of strategy and co-ordination between education and training and other key institutions. Also financial resources are scarce, firms also need to search to stretch their plant capacity and adapt overseas-designed products and productions processes to local conditions. Resources, government involvement and co-operative inter-firm efforts are necessary for all these activities. Yet, as shown below these supporting conditions are not always present in the case of semi-peripheral nations.

5.2 BRAZILIAN MACRO CONTEXTUAL CONDITIONS : IMPLICATIONS FOR HC PRINCIPLES APPLICATION

In the present section, based on theoretical framework above proposed, an examination is made of the institutional factors that might support or constrain the diffusion of HC principles in Brazil. Part 1 outlines how 'external' factors (ie, trade agreements, access to state-of-the-art-technology, TNCs and market orientation) might affect the introduction of HC principles at firm level. Because historical events explain the present national infra-structure, in part 2 a brief historical overview is developed. Part 3 examines the Indigenous Technological capability (ITC) that was created as a result of the industrialisation process of the 1970's. Despite the fact that the importance of the set of national institutions that affect the competitiveness of a nation have been widely recognised, the present chapter focuses on two key components that seem to be crucial for the implementation and diffusion of HC principles. Namely, the S & T system discussed in part 4 and the Educational and Vocational training system outlined in part 5¹⁴⁵. The last part, overviews domestic factors that might support or constrain the implementation of HC principles in Brazilian industrial firms.

5.2.1 MACRO INSTITUTIONAL EXTERNAL CONDITIONS SUPPORTING AND CONSTRAINING THE IMPLEMENTATION OF HC PRINCIPLES

As suggested in the previous section, four key factors, external to the country, influence domestic macro institutions performance. Their performance in turn, directly affects the implementation of HC principles at firm level. In this section a brief overview of these four factors is made.

¹⁴⁵ This does not involve downplaying other important macro factors. Above selected factors seems to be prime requirements for any sustainable (re)industrialisation process. The careful examination of all proposed macro factors goes well beyond the scope of this study.

Market Orientation: Despite traditionally being an inward-oriented nation, Brazil is quickly changing its industrial orientation. Since the late 70s, more and more government policies were directed to support export industries. Manufactured goods exports grew between 1965 and 1985 from 8,1 % to 54,9 % (Cardoso and Fishlow, 1990). Nevertheless, a significant percentage of exports are still commodities, semi-industrialised goods and mass produced low value-added products¹⁴⁶. This suggests that despite important improvements in export industries, Brazil does not have a clear specialisation in industrial terms. Industrial effort is highly dispersed and this seems to be connected with the sub-optimal performance of Brazilian firms and of national institutions that might support those firms in terms of training, know-how acquisition, technology suppliers agglomeration etc.

It should also be noted that the large domestic markets, regarded as Brazil's most important internal competitive advantage (Coutinho and Ferraz, 1994), is still being explored. Both TNCs, SOE and successful national firms seem to neglect this important market. Therefore, it can be concluded that Brazil's market orientation is weak as it neglects its large domestic market and; the high heterogeneity of its manufacturing infra-structure hinders the set up and development of specific macro institutions for supporting (specific) industrial sectors.

Access to state-of-the-art-technology: At international level, access to state-of-the-art technology is restricted to highly advanced nations. Another source of technology transfer is through TNCs. However, in the Brazilian case, empirical evidence has showed that this occurs to small extent or rather 'TNC may prolong technological dependence by institutionalising it in an international corporate organisation in which R & D activities are highly centralised in the home country' (Newfarmer, 1985:58). Therefore, it can be suggested that despite the existence of an ITC, Brazil faces a significant challenge as it is required to follow world high technology leaders to produce latest consumer and capital goods.

Transnational Companies (TNCs). There is little doubt TNCs have an important role for the industrialising process as they enjoy significant technological, market and economic power. In market terms, TNCs enjoyed a monopoly and oligopoly situation. This favoured high profit margins producing low value-added products or high value-added products with outdated technology. In economic terms, they possess enough resources to cope with domestic competition and to influence government industry. policies. This was true specially of the 1970s. TNCs are also directly linked to FDI flows. Nevertheless, empirical evidence pointed

¹⁴⁶ Coutinho & Ferraz (1994) have warned of the danger of this composition of export products, as commodities are getting lower importance due to the high supply of products and, hence, lower prices obtained in the international market.

out that TNCs investment 'generally has not transmitted the benefits of increased competition to Brazil' (Newfarmer, *op cit*, pp 343). In the early 1990s, the re-concentration of capital through wide spread industry fusion, generated more powerful TNCs. They are, more oligopolistic as a lower degree of contest occurred in 'their' markets as well as being more technologically powerful as more resources can be channelled to high technology R & D (Cano, 1993). In short, it can be suggested that TNCs favoured the industrialisation process in Brazil, but social development of the nation did not occur as the process was labour intensive and low wage driven (Freire, 1979). Thus, social inequalities grew parallel to the industrialisation process.

Trade Agreements: The wide spread of trade blocks suggests a 'regionalisation' rather than 'globalisation' of production and financial flows. Brazil, Argentina, Paraguay and Uruguay constituted the southern cone common market (mercosul). This is an important initiative to increase economic activity in these nations. Current trade flux among the two largest partners (Brazil and Argentina) seems to favour Brazil in trading of manufactured goods and Argentina in agro-industrial goods (Behar, 1991). Other regional common markets influence on Brazil trade flows but the extent of this is still uncertain. Nevertheless, some commentators (*cf*, Cano, 1993) have suggested that NAFTA (US, Canada and Mexico common market) as well as the European Commission block might hinder Brazilian exports as supra national institutions, together with TNCs, impose conditions that directly affect access to world markets. Just to mention some, (i) continue neo-liberal commercial policies, in order to allow easy access of advanced nations products to Brazilian markets; (ii) the establishment of agreements on intellectual and industrial property; (iii) further de-regulation of FDI. All this factors are subtle conditions of supra-national institutions (such as IMF, BID, BIRD) for access to international financial resources.

In Summary, ' [t]he current dynamics of globalisation may drastically increase inequalities of access to sources of foreign investment, the acquisition of foreign technology and access to foreign markets' (OECD, 1992: 257). Despite the negative evaluation of the influence of these four external factors on a latecomer nation development, we can only speculate about their interference on the implementation of HC principles at firm level. On the one hand, this trend may indirectly hinder the implementation of HC principles at firm level, as economic growth may be restricted. On the other hand, those factors can little affect the introduction of HC principles at firm level in the Brazilian context due to two reasons. First, TNCs are often the first to implement alternative organisational forms; second, Brazilian industry is characterised as having a low level of intensity of AMT; then, difficult access to state-of-the-art-technology may make the implementation of HC principles difficult. Therefore, at this point, we can conclude that externalities may not support the implementation of HC principles at firm level

but this does not prevent its implementation as key factors are more intra-firm related than extra-firm.

5.2.2 BRAZILIAN INDUSTRIAL DEVELOPMENT: AN HISTORICAL OVERVIEW

The current state of Brazil's industrial infrastructure can be credited to historical, political and ideological developments. The industrialisation process was characterised by: (i) the import Substitution Industrial strategy (ISI); (ii) a strong state intervention; (iii) MNC and state institutions alliances; and (iv) the spatial re-allocation of the international industrial production at world-wide scale, (Leborgne and Lipietz, 1988)¹⁴⁷. All this yield economic growth in the 1970's and economic stagnation in the 1980's that resulted in further social inequality.

Historical events: Since discovery times, Brazilian economy has been based on the exploitation of natural resources using slave labour. The 1929 crisis led the nation towards a shift in its development policy. The industrialisation of the nation turned to its large domestic market. This was the starting point of the ISI policy, which has aims to replace imported goods by local ones in order to promote the growth of indigenous firms. (Furtado, 1965).

After World War II, Brazil experienced high rates of economic growth. This was possible because of the expansion of the domestic industrial output¹⁴⁸. However, owing to the inward-oriented strategy of the 50's, problems with the management of the economy were experienced in the 1960's. Industrial growth meant not only economic expansion but also inflation and the enhancing of social tension¹⁴⁹.

From the late 1950's, inflation was used as a resource to attract savings, mainly from the general Brazilian population, for the funding of investments in the manufacturing sector. This policy was successful in its first stages. However, it contributed, to profound social

¹⁴⁷ This New International Division of Labour, led TNC not only towards the use of low-wage and docile manpower in Third World nations but they also sought the expansion of its markets as well as for the utilisation of tax advantages offered by host countries (Schoenberger, 1989:92). Indeed, dependent nations were interested due to the contribution of TNC activities in their economies. The establishment of TNC implied also in the existence of a domestic industry to supply raw materials and intermediate goods.

¹⁴⁸ Between 1947 and 1961, for example, the average of industrial production was 9.6 %; between 1957 and 1961 it was 12.7 % (Furtado, 1965:88).

¹⁴⁹ Baer (1983) suggests that the economic problems of the 1960's were due to the application of the Import-Substitution Strategy (ISI) which neglected its export promotion profile.

inequalities¹⁵⁰. The concentration of power with the elite (landowners) has resulted in a rigid institutional framework. It constrained political expression from the urban working class that emerged as a consequence of industrialisation.

Political/ideological events contributed also to the particular pattern of the Brazilian industrialisation. In order to prevent revolutions, USA exported, to Latin American nations, doctrines that linked industrial development policies to the military role (Stepan, 1973). The ISI strategy was suggested by the United Nations Economic Commission on Latin America. The global monetarism of the 'Chicago school' also, influenced the economy policy during the military government (Haggard, 1986:368-9). The key ideological issue developed among military cadres was sustained by the relationship between the 'national security' doctrine and national development:

An effective policy of national security demands a strong government. That can rationally maximise the outputs of the economy and effectively contain manifestations of disunity in the country (Stepan, 1973:55).

Keeping in mind this doctrine, the military justified the social and economic changes they promoted after 1964. Their goal was to industrialise the nation through foreign investment and intensive use of technology. For this a total absence of opposition was necessary (Bruneau and Faucher, 1981:3). That opposition was eliminated through repression¹⁵¹.

As a result of this, between 1965 and 1985 Brazil not only shifted from an agriculture-based economy to a manufacture-based economy, but also its economy grew on average 9.6 % annually. However, the relative external equilibrium, that has been obtained with export

¹⁵⁰ Furtado (1965) states that inflation is a process of redistribution of income for the benefit of groups linked to investment. "Other trends such as the agrarian structure formed from the colonial model based on natural resource exports also operated to increase social and economic inequalities. Between 1945 and 1965 for example, the ruling class in Brazil was almost entirely composed of great landowners. In the same way, slavery promoted a system in which labour relations were marked by profound social differences between employer and employee" (Furtado, 1965:93).

¹⁵¹ Simultaneously with the expansion of capitalism in Brazil, emerged what Petras (1987) called the 'global state terror network'. The USA foreign policy provided the know-how, training and funding of institutions and agencies to develop the repressive apparatus of state. The end of the democratic system and the imposed political 'stability' made possible all economic achievements during the 1960's and 1970's. The Brazilian 'economic miracle' was not only based on economic policies, but also based on :

- a) violent illegitimate seizure of political power by the military;
- b) the institutionalisation of violence through an extensive and intensive system of military-police controls throughout civil society;
- c) the systematic use of terror to contain popular discontent, to disarticulate mass organizations and to destroy guerrilla resistance;
- d) the elaboration of the national security ideology to justify the state's 'permanent state of war' against autonomous class or nationalist movements. (Petras, 1980: 332)

surpluses, can not be credited to successful industrial performance. Conversely, 'it has been gained at the cost of domestic imbalances' (Willmore, 1989). That is, the compression of wages to slow inflation rates; the current public deficit to finance monetary expansion and the exchange rate policy that it promoted continued to use small but constant devaluation to solve the problem of high cost linked with high rates of inflation. All of these measures contributed to the erosion of the standard of living of the general population. The heavy foreign debt is linked to this scenario.

The verticalization, the internationalisation of the economy and the decline of the dependence of imports are the principal features of the Brazilian pattern of industrialisation which continues to the present. This particular industrial structure reflects the consumption structure created after 1964. The way capital-intensive technology was used caused a decline in industrial wages (Baer, Fonseca and Guilhoto, 1987: 279-83). Other important economic determinants of the industrial structure were: the installation of multinational companies (MNC)¹⁵², the wide-spread growth of state-owned firms, tariff protection, advertising, minimum efficient scale and geographic concentration (Willmore, 1989: 1614). Despite the Brazilian industrialisation process was inward-looking, an important export capability was developed¹⁵³.

The *industry strategy* was based on the development of the durable (automobile) and capital goods industry. This strategy led towards the development of a sophisticated market-consumer based on high technology goods. Despite the fact that technology helped Brazil to be competitive internationally in various sectors (Sercovich, 1981: 138), its application did not produce greater employment and tended to pay well only a fraction of the skilled workforce available. The core of the manpower (unskilled) had to endure low wages. In spite of the increasingly urban working class, employers enjoyed total discretion to fix wages levels, because of the repression that the military government applied on social movements, trade

¹⁵² Despite that there are few doubts of the direct effects of TNC on the industrial structure and performance of developing countries, still there is not clear if the installation of TNC really contribute in positive way to develop the country host. (Newfarmer, 1985:58)

¹⁵³ This led us to the key theme of what industrial development trajectory was required to follow. While there was some support for the export-oriented path (cf, Balassa, 1981), others point out limitations of this policy: Kraugman (1989) suggested that the increasing flow of durable and non-durable goods from the NICs will go beyond what the markets and political capacity of industrialised nations can absorb. This will generate adjustment problems that stem from the high interdependence that exist among nations, mainly in trade and capital markets, of the two different realities - niches and developed countries. Lutz (1987) for example presented evidence of market shifts to the NICs at expense of the industrialised countries between 1968-82. To Haggard (1986), the solution lies more in the "political management of trade between these different socio-economic systems" (p.362) than in purely trade and economic policies. The current formation of trading blocks is seen as a promising alternative, that, however, need to be politically worked out in order to set up equitable world trade rules.

unions in particular. This strategy therefore further contributed to the unequal income distribution (Hewlett, 1980)¹⁵⁴.

State intervention both as regulator and promoter of development was intense. The state as economic agent, acted as banker and financier and as producer specially in basic industries such as telecommunications, petrochemicals and mining (Baer, Newfarmer and Trebat, 1976)¹⁵⁵. The institutional and economic base that allowed such an impressive growth of the Brazilian economy was caused by the 'alliance' of state, international capital and indigenous interests¹⁵⁶.

5.2.3 INDIGENOUS TECHNOLOGICAL CAPABILITY

Indigenous technological capability (ITC) is defined as possessing the ability to acquire or develop or improve new technology and, at the same time, assimilate both the formal and tacit knowledge that is required to achieve this¹⁵⁷. Callois (1984) has suggested an enlarged

¹⁵⁴ The overwhelming cost of the stabilisation program was carried by the poor. The wage policy imposed augmented the secular inequalities in income distribution. Economic policy-makers utilised wages income as a tool to manage it. As a consequence real wages were systematically reduced between 1964-67. Domestic capital necessary for investment, came from both revenues and taxes, and from the low income groups, through compulsory savings. These savings financed projects for the national capitalist (upper income class) (Fishlow, op cit, p. 85)

¹⁵⁵ For example, in 1974 government banks accounted for almost 65 % of the loans held by the 50 largest banks). A 1974's survey of 5,113 largest firms has shown that over 39 % of their net assets belonged to public enterprises.

¹⁵⁶ This is what Evans (1979), Cardoso (1973) and Faucher (1981) called *associate development*. This concepts rejects the traditional idea of foreign capital 'directing' the development path using the core-periphery relations, that is underdevelopment nations exporting raw materials and industrialised countries transferring outdated technology and enjoying the exploitation of the workforce with greater obedience of the host government.

"...the military implicitly assumed an identity between the economic interests of the entrepreneurs and the general interests of the nation... The system does have considerable social cost, but it has also opened up very promising opportunities for the absorption of the modern sectors of the middle class, linking them through self-interests to the international bourgeoisie ... the relative degree of stability achieved in the alliance among the military, the bourgeoisie and the middle class [was] .. because their internal contradictions were not as antagonistic as the treatment of development policy generally favourable to the popular class" (Cardoso, 1973:159-60).

¹⁵⁷ Several different technological 'learning' mechanisms are used by Brazilian firms and institutions. Each one requires a different type of state intervention in terms of policy, namely, (i) learning by doing requires market protection mechanisms; (ii) learning by designing, this might involve direct and deep state intervention to develop a new technology, such as the alcohol program as a substitute for petrol; (iii) Learning by integration implies for example, a state orchestration of efforts between a state research institute and the private productive sector; (iv) Learning by training, needs the support by the state of the general educational sector; and (vi) Learning by hiring occurs when private or government firms benefit by hiring personnel previously trained by state institutions (Goldman-Soligen, 1987:469).

definition of indigenous technological capability that overlaps, to a significant extent, with the HC principles. The definition included,

... the further possibility of full use of manpower; the formative capacity of jobs and the skill production in the firm. Then any form of work organisation which give more responsibility to different workers facilitate worker promotion and fight against task segmentation, contribute to enhance the indigenous technological capability (Callois, 1984: 216).

Because of the heterogeneous technological structure of Brazilian industry, we have divided firms in three categories to examine ITC: (i) the key strategic industries; (ii) successful national firms; and (iii) the majority of firms. While the first group enjoyed government support during the rapid industrialisation epoch, the second group benefited indirectly by the spill over of the key industries development. In the last group, firms are generally backwards.

ITC in Key Strategic Industries¹⁵⁸

Unlike the typical Schumpeterian private firms, State-owned Enterprises (SOE) were not only profit generating institutions but also instruments of official Brazilian industrial policy. That is, they absorbed, generated, and helped to create technological capability, employment and thus, contributed to diminish the technological dependence in strategic areas (Sarathy 1985). A ITC was created through the development of key strategic industries: petrochemical¹⁵⁹, aeronautics¹⁶⁰, capital goods¹⁶¹, defence¹⁶², electrical machinery¹⁶³, computer¹⁶⁴, telecommunications¹⁶⁵ and steel¹⁶⁶ industry.

¹⁵⁸ Because SOE played a more important role than TNC to build ITC in Brazil, in this section we refer only to SOE.

¹⁵⁹ The petrochemical industry, acquired the capability to design a complete refinery, everything related to the use of natural gas and little in the field of petrochemicals and fertilisers. (Fleury, 1989).

¹⁶⁰ The aeronautics industry (Embraer) captured about a third of the 15-19 passenger turboprop US market in the early 1980s (Sarathy, 1985:60). In effect, by that time, Embraer was the only non-American company among the top ten general aviation producers in the West (New York Times, 1985 cited by Fleury, op cit). Currently, based on the advantages of commonality, Embraer is developing two aircraft programs simultaneously. The 19-seat CBA-123 (built with Argentina's FAMA) and the 45-seat regional aircraft EMB-145. Other projects include Embraer participation in the MacDonnell Douglas MD-11 program to design and produce carbon-fibber out-board flap (Aviation Week and Space Technology, 1989:65-66).

¹⁶¹ The capital goods industry played a central role in economic development and technical change due to its inherent vertical and horizontal spill-over (Frasman, 1986). As the main instrument in the promotion of the ISI policy of the time, the state subsidised and protected local production. The acquisition of technological capability in this area allowed national production and exports in the made-to-order capital goods sector to grow 25 % between 1975 and 1983 (Paus, 1989; Faucher 1991). As a result, Brazil is the largest producer of capital goods in the Third World (China included) with domestic content supply comparable to that of advanced economies. It is also one of the main exporters of capital goods among LDCs (Erber, op cit). In summary, Brazil has acquired considerable mastery over both design and manufacturing of products ranging from single to complex one-of-a-kind capital goods (Chudnosky and Erber, 1986).

¹⁶² Brazil's defence industry is also an important economic sector. Because the state played an important role, the Brazilian defence industry, predominantly private, became in the 1980s the fifth largest defence hardware producer (eg, rockets, artillery, tanks, armoured vehicles etc) of conventional military equipment in the world. This industry promoted the development of indigenous technology. On average, the industry exports 80 - 90 % of its total output and the content of the value-added ranges from 60 to 80 % (Neto, 1991; Luria, 1989).

¹⁶³ The electrical machinery industry is one of the most technically advanced and fastest growing industries. It accounts for between 5 and 10 % of manufactured value-added in most industrialised and NICs. In the consumer goods field (lamps, TVs, electrical equipment) almost no indigenous technological research occurs. This is in contrast to what happens in the (electrical machinery) capital goods area, in which heavy equipment to generate and distribute electricity and specialised industrial equipment are the main products. At world level, those products are produced by a group of large TNC (Newfarmer, 1985). In this industry, a technological capacity to produce most of the essential products in the electrical machinery industry was installed. The consumer goods area was dominated by TNC branches and the capital goods market through the Eletrobras holding as well as the establishment of TNC branches (Newfarmer, 1980). This does not mean Brazil achieved autonomous technological capability but that the technological gap was minimised.

¹⁶⁴ The setting up of the Brazilian Computer Industry is another case of state intervention and development of the indigenous technological capability. As a result of the application of targeted policies and other events, between 1979 and 1985, the Brazilian computer sales grew at an annual average of nearly 60 %, and in the same period the number of direct jobs in the sector grew at an annual average of 47 % (Fleury, 1988:29). Out of the economic goals, the technical and human infrastructure created by these policies were the most important achievements. It gave greater future potential to indigenous Brazilian computer firms, when compared with other niches, such as Korea (Evans and Tigre, 1989).

Policies were based on (i) state intervention to encourage indigenous firms to favour the development of indigenous Science and Technology knowledge; (ii) the diversification of technological dependence among a wide range of international producers in order to minimise the risk of total technological dependency and (iii) to create a reserve market for micro-computers leaving the large-sized computer segment to TNC (Rada, 1982:82).

Two key additional factors triggered its successful evolution. One was the presence of ideologically motivated people and state institutions, that managed to develop a base that could help to convince policy-makers of the technological and industrial viability of domestic ventures' (Adler, 1988:60). The other was the evolution of the international computer industry. The explosion of sales in mini-computers created space for the Brazilian embryonic industry (Evans, 1986:797).

¹⁶⁵ The Telecommunication market is divided in two major sectors: (i) the demand side comprised of telecommunication services or carriers networks - usually provided by government bodies; (II) the equipment supply sector whose demand is divided from the telephone and telegraph administration (Hobday, 1985:315-6). This Industry played a major role in national development. The first priority was to develop 'capability accumulation' to develop a local Telecommunication industry. This was made following two strategies, namely (i) directly developing core technologies via government R & D efforts and (ii) indirectly, setting up policy mechanisms to ensure TNCs branches transferred ownership and key technology from their parent companies (Hobday, 1985).

¹⁶⁶ The Steel industry is another example of acquisition of internal technological mastery. Because of heavy state investments in the area, the formation of strategic joint ventures with foreign capitals and the internal technological capability developed to assimilate new equipment mastery, the Brazilian steel industry grew 331 % between 1967 and 1980. That is, with the exception of South Korea, it was the fastest growing rate amongst all the major steel producing markets economies. It should be noted that in 1983, 66 % of the steel industry was government controlled and the remanding 33 percent were of local private capital or foreign capitals (Foot and Webber, 1990:93-6)

The emergence of government-sponsored key strategic industries have contributed in significant terms to create an ITC in their respective sectors. These firms, in general terms, used extensively all the available learning processes to absorb enough knowledge and experience in order to develop/improve products and productive processes. They not only supplied the domestic market but also exported part of their output. An extensive diversified network of research centres was installed. However, in some sectors, such as informatics, it is still debatable whether this industry was successful or not¹⁶⁷. The installed institutional R & D capacity that key strategic industries developed are an important factor that supports the implementation of HC principles, as both technological and managerial capacity is needed to cope with volatile markets.

ITC in Successful National firms

Successful national firms¹⁶⁸ possess five key features. First, they are usually private owned and exporters and are large in size; second, they have a network of relationships with

¹⁶⁷ On the one hand, some studies (cf Evans and Tigre, op cit; Schmitz and Hewitt, 1992), for example suggest the success of this industry is due to the creation of technological capability. On the other hand, based only on economic indicators, World Bank (op cit) challenges that view. The important point however, is that success should be measured not only on economic but also institutional and infrastructure creation terms. Therefore, using this criteria, it is possible to suggest success; but using only economic criteria (cost of final product) is possible to conclude failure. The use of tariff protection for example, continues to be debated. While in early stages of the industrialisation process, tariffs assisted 'infant industries' protection does not promote the achievement of competitiveness. However, it has still not been proven what the negative effects of applying protective mechanisms really are (OECD, 1991:72).

The view developed here is that, the evaluation of success or failure in key industries should be based not only on economic criteria, but on the technological capability acquired. That is on the created domestic capability to (re)create products, processes and services. The significant degree of exports that those industries have achieved is the most concrete evidence of their success. Moreover, the spill-over that these key industries created was absorbed by some national firms. They were able to capitalise on the capability created by the key industries.

¹⁶⁸ The principal features of successful firms are (Katz, 1987),

(a) In general terms, the principal features of Latin American firms are: (i) low degree of AMT diffusion when compared with industrialised economies, which mean that more universal and manual equipment is the rule. Hybrid productive systems (blend of high and low technology equipment) are common; (ii) the technology selected needs less sophisticated maintenance; (iii) the internal transport system (intra-firm) are usually labour intensive; and (iv) a high ratio labour/capital exists in general.

(b) The search process for new technical knowledge occurs, usually, in the applied engineering end of the knowledge spectrum. Therefore, both basic and applied research are restricted to firms only producing high technology products. The majority of enterprises prefer to concentrate in those areas in which only low investment is necessary, no highly specialised personnel (eg, scientist) needed and in areas where results are more visible and accountable. That is, in priority order, the majority of firms focus on product engineering, process engineering and production (industrial) engineering as the areas in which their search for technological innovations are concentrated.

In the product engineering field, incremental improvements to existing products, such as tools, dies and jigs are made. The search for alternative innovation using the existing equipment is the basic task of process engineers. The reorganisation of production operations and labour deployment are the main activities of production engineers. Usually, only large national firms have sufficient capacity to deploy personnel dedicated to this task. The goal of these activities in the above areas is not necessarily cost reduction Other kinds of

suppliers, consultancies for specialised matters, training institutions as well as commercial and government contacts. Through interaction with these bodies, the firm acquire other type of experience and knowledge. Those external bodies assimilate practices used inside the firm as well; third, these firms deal, mainly, with the adaptation of imported technologies to local conditions. Their principal technological efforts are determined by the need to (i) use different raw material; (ii) scale down plant size; (iii) diversify product mix without incurring any further capital investments; (iv) adapt product design; (v) use simpler or lower capacity machinery and (vi) stretch capacity of existing equipment (Tietel, 1984:56); four, in organisational terms those firms are applying new management and production engineering techniques, such as JIT, TQM, SPC, cellular manufacturing and work group, in order to meet market targets in terms of cost, quality, reliability and lower lead times (Ferraz et al, 1992; Fleury and Humphrey, 1993); five, R & D intensity in these firms is significant¹⁶⁹, but oriented to 'minor' innovative activities. Coping and imitating through reverse engineering was the general rule¹⁷⁰.

The contribution to the acquisition of technological capability of these firms is two fold. Firstly, towards the promotion of endogenous spin-off mechanisms and secondly, towards the positive influence to external firms such as suppliers and local customers, among others.

This is relevant to the implementation of HC concepts, because it suggests that Brazilian firms are more prone to use alternative production concepts than heavy investment in capital-intensive technology. One obvious reason may be the relative low cost to introduce organisational changes when compared to the introduction of equipment. This attitude provides a positive cue concerning the predisposition of Brazilian managers to adopt

innovation are more important, such as quality improvement, the search to widen the product mix or the adaptation of foreign methods/machines to local conditions, (ie, the use of different components, parts or raw materials), or the search to stretch the output capacity of the existing equipment.

(c) The main macro factors that influenced the above mentioned firms behaviour were (i) high cost of equipment favours a strategy towards the stretching existing equipment; (ii) subsidies to capital expenditure favours capital intensive equipment acquisition (usually only large firm can cope with 'risky' behaviour; (iii) because of high interest rates, firms try to reduce their stock of work in progress but enterprises prefer to look for output-stretching capacity rather than quality improvements; and (v) the general unavailability of skilled personnel in manufacturing firms (eg, personnel with skills in applied research in new materials or production engineering techniques) favoured the concentration of effort in more 'common' areas such as the above mentioned (product design, process and industrial engineering).

¹⁶⁹ A detailed study (Marcovitch, 1992), pointed out that more than 200 firms are investing in R & D, and of these approximately 50 % invest heavily and systematically. These firms possess updated enterprise strategies which identifies, treats and finds opportunities in the business environment, fine tune their technological responses to their environment, as well as being clearly export-oriented.

¹⁷⁰ Braga and Matesco (1989) survey (cited by Dahlman and Frishtak, 1991) showed that only 23.5 % developed new products in a systematic way.

alternative organisational forms and is a favourable condition for the introduction of HC concepts. Additionally, the 'model' role that successful national firms play is another important favourable reason for the diffusion of the HC model.

ITC in the majority of firms

In the majority of firms, both technological and organisational innovative activities are uncommon. These firms are more worried about trying to cope with difficult macro-economic conditions in order to continue operating in the market, than in trying to improve their facilities. Therefore, they usually pay little attention to their productive processes. This was widely shown in Brazilian data¹⁷¹.

The acquisition of technological knowledge was difficult in this group of firms, because (i) the lack of skilled personnel and the scarce resources available to use national or foreign research institutions; (ii) use of extensive conservative thinking in management practices (eg, familiar-owned and operated firms further complicate the picture); (iii) negative forms of dependence on imports or output markets; and (iv) difficulties to finance access and low level of skills availability in general (Smithz, 1982).

Outcomes of Brazilian Indigenous Technological capability

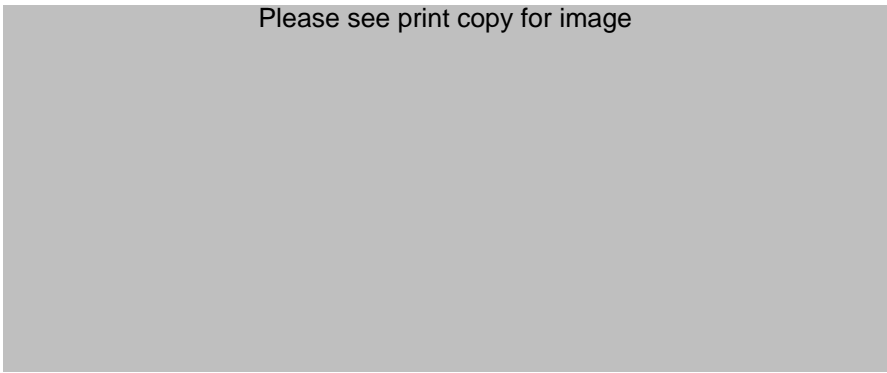
Because of the nature of the technological innovation performed in the majority of Latin American firms, that is, through minor technological improvements (Katz, op cit), it is difficult to measure their performance. This fact however, does not minimise their importance. A reliable indicator of the degree of maturity achieved by Brazilian manufacturing firms is the extension (in qualitative and quantitative terms) of the capital goods sector exports. Capital goods exports imply the development of basic technological knowledge. This will include process knowledge as well as high levels of design skills and manufacturing experience. However, because export activities are the result of a complex interaction of different factors, it is difficult to assess the degree of maturity achieved in the manufacturing sector.

¹⁷¹ Braga and Matesco (op cit) confirmed that there was only a little innovative activity performed. From 4.309 firms operating 7.156 plants they found that stock control activities were performed by over 92 % of the sample, but more than 81 % did it manually. In the same way, quality control activities were performed by 93 % of firms, but only 28.8 % used modern methods such as statistical process control.

Fleury (1988) observed similar behaviour in his survey. The majority of firms (47 %) adopted a 'partial' approach to modernisation. That is, they adopted the strategy to acquire advanced manufacturing equipment without any major effort to re-organise both the administrative procedures and work organisation practices. 24 % of the firms, used a 'conventional' approach to modernisation. That is, they did not invest either in equipment nor in new organisational strategies nor in internal training.

Overall resource endowment, including stock of human capital, determines potential comparative cost advantage; firm strategy and country policy affect the realisation of potential advantages and the relative profitability of exercising them through different means; strategy and policy influence comparative advantage through their effects on human and institutional capital accumulation (Dahlman and Sercovich, 1984:97)

It should be noted that economic indicators such as relative prices, export/import levels etc., did not reflect the whole picture. Firstly, it does not necessarily mean a backward situation for Brazil, but the speed of economic growth experienced by other nations. Second, when socio-institutional factors created capability, such as the creation of indigenous technology learning and creative capacity, the real extent of social, economic and institutional development are included (Dore, 1984). Two aggregate indicators that reflect the competitive position of Brazilian industry are used. First, the 1994's World Competitiveness Report (1993) pointed out that Brazil's export performance is on average with other NICs; this is significant as Brazil development path is not export-led. Second, Exhibit 5.2 illustrates that Brazil not only possesses the highest ratio of diversification of production in Latin America, but also its industrial value-added level is above that of several other NICs.



Source: Fichet (1991) based on UNIDO (1988) Handbook of Industrial Statistics, Vienna.

Exhibit 5.2: World Ranking of Countries in terms of Industrial Activity, 1985

High Value-Added Brazilian exports occur in other areas besides the traditional ones such as commodities and consumer goods. These are: (i) technical services (pre-investment studies, design of engineering projects such as entire turn-key alcohol or ethanol plants, and product engineering, engineering consultancy and licensing); (ii) management services for large projects; (iii) production management for newly established plants or in other embodied activities such as physical construction of highways and design/fabrication/assembly of industrial facilities (Dahlman and Sercovich, 1984).

However, Brazilian achievements in high value-added exports vary depending on the particular features of the sector and firm. This is because of the dynamic nature of the

indigenous technological capability accumulated and because of the volatile nature of those markets. No generalisation can be inferred at firm or sector level¹⁷².

Turnkey and made-to-order capital goods-related technology exports sometimes show up a trend towards increasingly technological self-reliance and sometimes they do not. For instance, they may convey the full range of Brazilian-mastered technological capabilities, from conceptual design engineering down the scale; or they just involve some detail engineering and post-sale services and be entirely based on foreign-supplied design and specifications. This depends a lot on what is being sold and to whom. In both cases technology may be exported through the same mode of operation but the underlying significance of the operation differs. The same observation applies when the comparison is drawn between foreign-controlled and domestically-controlled technology exporters.

Sometimes technology exports are associated to mostly in-house learning processes; others reveal a rather diffuse, inter-firm learning process. For instance there is no doubt that in certain specialised items of sophisticated machinery and equipment the first kind of situation prevails. But the second is truer of the experience of traditional and biomass-related industries. Most industries are likely to fall somewhere in between these two situations. (Sercovich, 1984:595-6)

In *economic terms*, both the stock of knowledge accumulated and the capacity created to organise it, possess characteristics of capital (Zeleny, 1991). That is, 'learning to learn' (Stiglitz, 1987) must be approached as an important additional factor of production that can be accumulated for purposes of expanded production activities such as the generation of new products/services. In *developmental terms*, the stage achieved by the manufacturing sector means that technological capability¹⁷³ was installed. Because of the tacit components of that technological capability, it is not likely to vanish (Faucher, 1981).

The Competitiveness of Brazilian Industrial enterprises

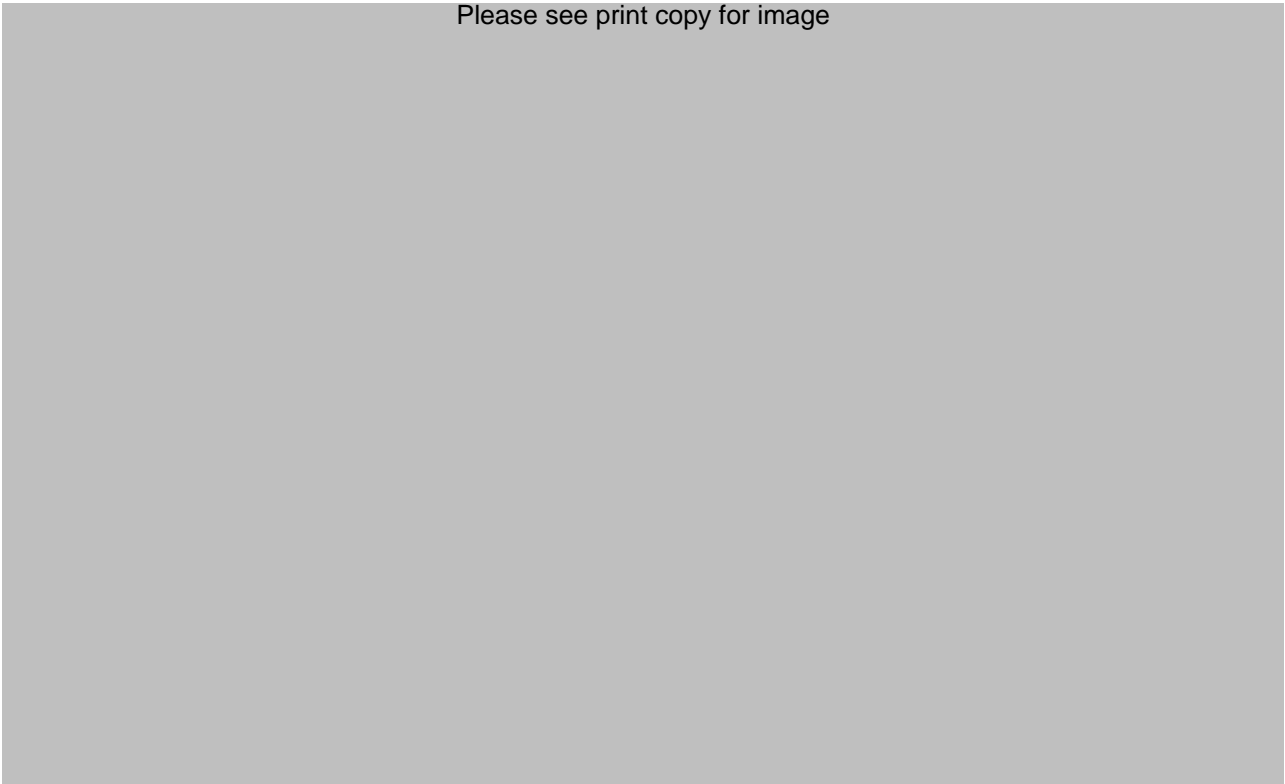
The major 'Study of the Brazilian Industrial Competitiveness' (SBIC) (Coutinho & Ferraz, 1994), classified economic sectors in (i) sectors with competitive capability; (ii) sectors with

¹⁷² Another indicator of the significant degree of absorption of technology by Brazilian firms is the emergence of Brazilian multinationals which compete vis-a-vis with other TNC in world markets. Wells (1988) estimated that Brazilian multinationals had spent US \$ 1.1 billion in foreign direct investments up to 1986. The main competitive advantages seem to be both the managerial skills accumulated over time and the know-how acquired to adapt imported advance technologies, organisational arrangements and methods to a third world environment.

¹⁷³ In effect, Brazilian developmental strategy -oriented towards technological autonomy - of the 1960s and 1970s was right at the time it was formulated, as Dore (op cit) pointed out, 'Minimisation of foreign trade (the minimum necessary for imports of capital goods and technology) plus a vigorous policy of building ITLC [indigenous technological learning capacity] and using it for large-scale technology import is a perfectly viable development strategy if your ITLC is really good and your economy is big and resource endowed enough' (p. 68).

However, the static application of the above policies during the last two decades, have lead to the current crisis situation.

deficient competitive capability and (iii) key sector for the diffusion of technical progress. (See Exhibit 5.3 below).



Source: Coutinho and Ferraz, (1994: 343).

Exhibit 5.3 : Classification of Competitive and non-competitive Industrial sectors

The first group has a positive performance. However, it focuses on intermediate consumer goods and commodities. Additionally, the share of manufactured goods in this group is increasing (from 30 % in the 1970's to 60 % in 1992).

The second group includes sectors in which a large proportion of products come from firms that have low degree of competitiveness. Two sectors are directly linked to the present study: the automobile and auto parts. The SBIC reported that these sectors posses limited competitiveness despite the existence of technical and managerial advances. Key advantages in these sectors stem from: low wages, flexible manpower interested in learning, capability to manufacture complex products with outdated machinery and the existence of abundant and low-cost raw materials.

In the third group there are firms that are highly threatened by both the domestic economic crisis and the opening of the economy. Because they are linked to high technology products/processes, they need investment to sustain competitiveness. Among sectors of this group, two are related with the present research: the machine tool and agricultural machinery industries. In the former case, the SBIC pointed out that firms were competitive in manufacturing standard conventional machine tools. But, their competitiveness is decreasing

due to the higher microelectronics content of the latest generation of machine tools. In the latter case, these firms are in the worst situation for achieving competitiveness because new processes in technology were not widespread.

In general terms, the competitiveness of Brazilian industry has been qualified as "fragile" (Coutinho, 1997). This is because it is based on the production of commodities. Therefore, Brazilian domestic technological efforts can be located,

... a few decades behind the Japanese or Italian 'catch-up', on a more reduced scale, and within the context of much greater market imperfection and structural weakness, specific industrial sectors of the niches of Latin America are sharing increasing signs of economic and technological maturity even within the midst of relatively backward domestic developmental situation (Katz, 1987: 47).

The evaluation above provides an idea of the high heterogeneity achieved by firms among and between deferent sectors. This will be the context in which the firm level examination made in part II of the present study should be understood.

5.2.4 THE SCIENTIFIC AND TECHNOLOGICAL SYSTEM OF INNOVATION

The scientific and technological base of a nation is one of the pillars for achieving industrial competitiveness. Industrial innovation¹⁷⁴, in semi-peripheral nations, search for evolutionary/incremental innovative activities at the lower end of innovative activities, rather than searching for 'revolutionary' product/process/ material innovation. That is, improvements to existing products and processes, as well as alternative applications, are the general rule. In this sense, innovative efforts are directed to (i) adapting imported technology to local conditions; (ii) searching for new uses for existing productive facilities; and (iii) searching for incremental innovations in both existing products and productive processes. 'Reverse engineering' mechanisms, for example, are used quite regularly at the industrial level. These mechanisms may bring better pay off in terms of accumulated knowledge rather than the simple purchase and installation of equipment (Katz, op cit). Traditional engineering activities performed at design, production engineering and process engineering stages are the most

¹⁷⁴ Innovative activities involve a set of different activities towards one specific goal and are supported by a particular configuration of institutional, economic, social and political forces. These, in turn, provide to a greater or lesser extent, the material conditions which favour, to different extent the release of the desired product (or process).

"The whole process of technological innovation has to be conceived as an on-going search activity - a search for products possessing new or better combinations of performance characteristics, or for new methods of manufacturing of existing products. But this search activity is shaped and structured in fundamental ways not only by economic forces, but also by state of technological knowledge and consumer demand" (Kline and Rosenberger, 1986: 301).

common forms of innovative activity in developing countries. It makes sense, therefore for semi-peripheral nations to concentrate on their institutional policies in support of the second order innovation. This converges with the HC philosophy for promoting full utilisation and regeneration of industrial skills. The existence of a S & T capacity therefore seems to be an important pre-requirement that supports adaptation and diffusion of the HC model.

The main means used to develop, absorb and adapt 'technology' in Brazil can be classified into two groups. Firstly, the traditional 'technology transfer' mechanism based on government regulations such as foreign direct investment (FDI), licensing and joint ventures. Secondly, reverse engineering. The latter, are the most important sources of technology (re)creation, absorption and adaptation at firm level, outside the key industrial sectors supported by the government or financed by TNCs.

The above two forms of acquisition/development of technology are the result of two different strategies from the political-economy perspective. The first group (eg, FDI, licensing) is a product of macro policies implemented to create favourable conditions to buy/transfer foreign developed technology. The second group of innovative activities is more a product of efficient management at plant level rather than any specific public policy¹⁷⁵. Specific policies were implemented to favour technology transfer/creation. The state also carried out a program to support and create a network of co-ordinatory institutions to link and match basic/applied research with industrial needs, industrial training and commercialisation efforts. The marginal participation of the private sector participation in formal industrial R&D activities¹⁷⁶ and the

¹⁷⁵ In spite of strict import regulations, Brazilian policy towards foreign investment has been one of the most open among the developing economies (World Bank, *ibid*). On average, up to 100 % of foreign ownership is allowed in most areas with the exception of the government-defined 'strategic' sectors. In effect, Brazil possesses the largest stock of foreign capital of any developing nation. The main proportion of *Foreign Direct Investment* - FDI (75 %) is held in the manufacturing sector because of the existence of specific sectoral programs such as the automobile and capital goods industry. Those programs provided fiscal and financial incentives as well as protection in local markets in exchange for performance in investment volume, local content and exports (Dalhman and Frishtak, 1991:25).

Technology Import Regulations involved both embodied and disembodied technology (eg, licenses and technical services) imports which were government controlled and oriented towards the strengthening of the domestic technological basis. This pursues the improvement of general local capabilities and the minimising of foreign currency outflow. In general terms, they favoured local firms to the detriment of foreign ones (Dalhman and Frishtak, 1991:20). These mechanisms used, however, were an important mechanism in setting up an ITC.

¹⁷⁶ Because private enterprise investment in R&D activities is very small, central government funds are mainly responsible for R&D activities. In 1983 for example, out of 1,118 firms - 43 public and 1075 private - state owned enterprises accounted for the majority of R&D expenditure (62.6 %) while only about 25 private industrial groups accounted for 17.4% of the total. The above figures are a reflection of the way researchers are distributed. 91.6 % of researchers work in state enterprises or institutions but only 2.0 % work in private research institutions or firms (Paulinyi, 1990 and Paulinyi, (1984) quoted in Dahlman and Frishtak, 1991).

establishment of S & T policies incompatible with general economic macro-policies were two main features of implemented S & T policies.

Brazilian S & T development occurred selectively. The state network of R&D related institutions covers very diverse areas from basic research in biology, physics and chemistry to more 'applied' research goals such as aerospace, informatics and agriculture. In the table above, other institutions with co-ordinating roles, the dissemination of information and institutional development are also included¹⁷⁷. However, high developed S & T areas co-exist with general technological backwardness. This can be attributed to the specific policies and instruments tailored to support a quick growth of selected 'key industries'. Successful national firms managed to absorb spill over and the majority of firms remained marginalised from this process.

The results of the established R & D structure are debatable. On the one hand, some economists (cf Dahman and Frischtack, 1991) have qualified Brazil's R & D as "not very effective due to the generally weak linkages with the productive sector" as well as the lack of specialisation. On the other hand, referring to the telecommunications industry, Hobday (1990) pointed out that the most important outcome was the generation of a local capability to acquire/improve/adapt more technology and, at the same time, create a highly skilled labour market in the nation. Therefore, from the economic perspective, the existing R & D structure is not very efficient, but, from the socio-developmental view, the R & D structure has achieved its most difficult task: ie to create an indigenous capability in the selected industrial areas. In other words, an important build-up in the basic R&D infrastructure occurred (World Bank, 1983) as a result of the general technology policies implemented during the 1970s and 1980s.

The S & T system affected differently key strategic industries, successful national firms and majority of firms.

(i) S & T in Key industrial sectors: Scientific development, defined by the government as a priority to achieve state-of-the-art research, has occurred in five areas: informatics, fine chemicals, new materials, precision mechanics and biotechnology (Guimaraes, 1990). There

¹⁷⁷ This does not mean that Brazil has a strong S & T apparatus. Salam and Kidwai's (1991) comparison of the S & T figures for Brazil and other semi-industrial economies (eg Argentina, Mexico, Korea), show that Brazil's performance is lacking in the main indicators with the exception of the average expenditure per R&D scientist or engineer. While Brazil, like Mexico, spent 0.6 (% of GNP) in 1982, Korea spent 1.1 in the same period. Nevertheless, because R&D expenditure at world level tends to be concentrated in a few nations, this is not an exclusively negative feature for Brazil or other developing nations. In 1985 for example, 'the major seven' OECD members accounted for more than 91 % of the total R & D expenditure (OECD, 1989).

are both advantages and disadvantages in this option. The creation of a real ITC in those selected areas, in some cases near and in other behind the world state-of-the-art, is the main advantage¹⁷⁸. The main disadvantage is the spread of short funds and efforts among very diverse areas. In consequence, shortage of funds will always be present in all areas.

(ii) S & T in Successful National Firms Those industries were not targeted by government S & T policies. However, a small group of firms managed to absorb spill-overs of the established S & T infrastructure. Their competitive stance was the product of the combination of internal innovative efforts associated with particular intra-firm policies in regard to training, wage system, industrial relations, as well as the selective use of S & T created. Those firms used government loans, laboratories and technical facilities set up by key industries and also attracted skilled personnel from Key industries. External forces (eg, balance of payments, foreign debt and flux of foreign capitals), in some cases, acted as a brake and in others acted as a push-force, but contributed, to a significant extent to the success or not of the general technology policies implemented.

(iii) S & T in the majority of Firms : Small and medium industries continued using basic techniques because: (i) they were not directly included in the above policies and ; (ii) they did not enjoy State financial and training support. Nor were they favoured by the easy transferability of technical cadres because social mobility between sectors occurs mainly upwards; (iii) deliberate government policies to not fund basic education properly and basic research outside the selected key industries; and (iv) the lack of research/incentives and co-ordination policies to improve/promote 'transfer' technical knowledge between and amongst industrial firms.

On balance, it is suggested that, in spite of the existence of a domestic R & D capability in selected sectors, the S & T infrastructure at a national level is not sufficient to support the development of the nation. This capability needs to be extended to the majority of firms in order to cope with the always fluctuating market conditions.

¹⁷⁸ Negative outcomes also occurred. In the nuclear industry, for example, because of the top-down strategy chosen to develop this industry and because of the exclusion of the scientific community, there was a lack of integration between industry policies, academic resources available and their own nuclear program. As a result, few innovative activities occurred in this case (Goldman-Soligen, 1987)

5.2.5 THE EDUCATIONAL AND VOCATIONAL TRAINING SYSTEMS

A nation's industrial productivity and standard of living seems to be directly linked to its schooling and training systems (Dertouzos et al, op cit; King, 1984)¹⁷⁹. Besides the existence of an educational infrastructure, this involves the setting up of adequate institutional mechanisms to co-ordinate educational efforts between Science and Technology and Industrial areas. Co-ordination mechanisms are needed to avoid typical problems of developing nations. Educated unemployed, the excessive stress in credentialism and government educational policies that only target formal economy sectors, (Whiston, 1988). It also involves making decisions under assumptions that are usually taken for granted¹⁸⁰. Brazil possesses a highly heterogeneous educational system. The primary and secondary schooling system, the undergraduate and the graduate sectors were developed differently both qualitatively and quantitatively. Next, a brief overview of the development and status of the Educational and Training systems is provided.

Significant changes occurred in the Educational system as a response to the economic growth process experienced during 1970s. That is, both economic and political factors promoted the utilisation of the educational system as an instrument of economic policies¹⁸¹ (Planck, 1987).

¹⁷⁹ However, there is no general agreement in this statement. On the one hand, for example, Maglen (1990) presented evidence that challenges the linkages between human resources quality and improvements in the productive base. On the other hand, Woo (1991) presented evidence of successful planning and economic achievements in the case of Taiwan.

¹⁸⁰ These assumptions are usually ethical and conceptual in nature, Whiston (op cit) asserted, "Thus one must surely inquire into the aims of technological development, scientific application, education and training activities. Is it to further the 'corporate state' ? Is it to maximise commercial productivity through more sophisticated automation ? Is it to improve one nation's economic and commercial advantage over other's ? Is it to ensure the most effective control over ecological damage or pollution ? Is it to enable the achievement of a more flexible, more intimidating armaments or defence program ? Is it all of these things ? (p.14)

Whilst co-ordinating measures are important to cope with increasingly changing needs of skills at industrial level, they are not only 'technical' problems.

"... the resistance to this [to change educational, training and industrial practices] are not due to lack of recognition of the problem, but institutional barriers, personnel prejudice, value structures and lack of perceived self-interest. Such difficulties and their solutions are political, cultural and psychological in nature, not coordinatory" (Whiston, op cit, p. 38).

¹⁸¹ In economic terms, the high rate of economic growth achieved in the 1970s called for the expansion and sophistication of the educational system in order to cope with the increasing demand for skilled workers, technicians, engineers and managers that the industrial sector required. It was used as an instrument of economic growth. However, the economic growth of the nation did not necessarily mean upgrading the standard of living of the general population.

In political terms, these changes reflected the current political system which pursued the legitimisation of the state as a source of power and political authority and, at the same time, supporting the interests of the elite. That is, it was used as an instrument for the different power groups involved: state bureaucracy, politicians, state government bodies (military), growing national industries and multinational companies interests. All of these competed for the control of public resources:

First, a decentralised educational system was replaced by a centralised hierarchical system. Second, a participative co-ordinating body was excluded and replaced by the raising of a technocracy to manage educational matters. Third, political criteria and public discussion were replaced by technical criteria and by a planning structure developed and controlled by the technocracy (Sobrinho, 1985).

Besides these structural changes, new problems also appeared. First, strong state interference in the economy changed the economic value of work and education. Sobrinho (op cit) suggested that '... salaries paid were a function of training received and no longer corresponded to the overall productivity and profit' (p.4). Second, this extreme reliance on formal education and training triggered the use of educational certificates as a means to access the labour market, leaving out experienced personnel without formal education (Blaug, 1979; Dore 1976). Third, the existing income inequality in the nation was also reflected in the access to the educational system¹⁸². In general terms, after 1964, educational government policies stressed the expansion of educational areas related directly with labour market demands and neglected social science areas at all levels. The level of development of the Educational system was reflected by public expenditures. Aggregate data (UNESCO, 1990) indicates that the pattern of public expenditure in Education clearly favoured both the primary and tertiary level in detriment of secondary¹⁸³.

The resultant Education policies promoted greater social inequality. This is because the neglect of both primary and secondary education means the segregation from an early age, of

"The terms of the competition have at least as much to do with patronage as with policy: successful politicians use public expenditures to reward clients and allies and to woo additional supporters. Political survival and the maintenance of the political stability take precedence over policy change. Lacking access and influence, the rural and urban poor fare badly in this competition" (Planck, 1980:540).

¹⁸² Reis and Barros (1991), based on census data (1976-1986), concluded that wage inequality is intrinsically associated with differences of wage-education profiles and not the contrary.

¹⁸³ Public expenditures in education between 1976 and 1985 reflected the expansion rates at different levels. The primary one, for example, consumed 45 % of the budged and expanded 165% + 21 % (including pre-school level). Secondary education spent around 10 % of the budget and expanded 84 %, and tertiary education received approximately 20 % of the budget and grew (31 + 64) 95 %. It is noticeable from these figures, that the apparent main rationale behind this pattern of development, was the support for the development of agriculture as well as of science and technology sciences. Other areas were neglected. Nevertheless, when the distribution of public expenditures in Brazil is compared to other similar countries, no homogeneous pattern can be identified. Mexico, for example, gives priority to the tertiary sector but Argentina emphasises its secondary educational level. The striking difference is Korea, in which the primary level is heavily funded by state (45 % of the budged), followed by secondary (38 %) and finally the tertiary level (10.3 %). That is, it provides education at basic levels (primary and secondary) to the general population and leaves the more sophisticated and expensive educational tasks of tertiary education to private institutions (UNESCO, op cit).

the economically depressed. Students with sufficient means may go to private schools and obtain a better education. They are, usually, the ones able to pass the rigorous entry examinations to tertiary education. Government Tertiary education, is free and of good quality. However, only the wealthier sector of capable students is able to enter public universities. The rest, who usually obtain clerical jobs, go to low quality private institutions. Therefore, the actual distribution of resources in the Brazilian educational system promotes higher inequality of access to free education at all levels¹⁸⁴.

Vocational Education and Training

The main question regarding vocational education and training is, whether vocational training programs should be carried out by the formal educational sector (at secondary level for

¹⁸⁴ At Primary level, services, infrastructure and outcomes are low in both qualitative and quantitative terms. Reforms attempted to correct this structural problem have failed due to: (i) lack of political will and consensus to favour change among and between politicians and educational administrators; and (ii) presence of conflicting interests within the educational apparatuses and within the Brazilian society in general terms (Planck, 1990). Adult literacy percentage was always the lowest when compared to other NICs. This is reflected in the high rates of school dropouts: 78 % of Brazilian students entering to grade one do not complete primary school. This figure is high compared to Argentina's 19 % and Mexico's 25 %. Psacharopoulos and Arraigada (1989) point out there are two main factors that explain this. First, the level of household financial resources and secondly, the demand for child labour by the household. These factors differ depending on the geographical area. In the northern regions (less developed), incomes are low and this necessitates use of child labour in order to help with the household income. 1 in 10 children do not attend school in this area. Conversely, in the well endowed southern regions only 1 in 2 students do not attend school. This is a failure of policy-makers and government to provide basic education to the total population.

Secondary education is predominantly private due to weak government funding. Two main features are worth mentioning. First, there is a strong correlation between private schools and access to prestigious public universities. Second, changes introduced after 1964 involved the vocationalization of all secondary education. That is, secondary education provides both general and specific training for work (Sobrinho, op cit). This resulted in the minimisation of enrolment in the humanities. Besides this, due to the small amount of government funding, the outcome of the vocationalization of secondary education was a failure. That is, in qualitative and quantitative terms, vocational secondary schools were not able to provide a variety of skills that the different industrial sectors demanded.

At the tertiary level, a significant physical and human infrastructure was created. Government funded University research institutions as well as SOE research facilities. This ensured the availability of highly trained professionals in selected areas to supply skilled manpower to growing key industries and pursue the 'technological autonomy S&T strategy. An important reason that triggered this development was the 1968 University reform towards the adoption of the American model of departmental structure. This reform aimed to transfer power to departments and research institutions. There were two outcomes which resulted from this reform: (i) the creation of successful/high quality academic research with overseas trained personnel in particular areas; and (ii) the expansion of the University system through the creation of full time faculties. However, there was insufficient staff with appropriate academic qualifications to work at this level at this time. This meant that part-time teachers were recruited as full time without the need to increase their academic standards. This created a structure in which well endowed academic departments with well qualified academic personnel carried out research and graduate education, while the undergraduate education was left to under qualified staff (Schartzman, 1988:104). In 1989, for example, Ministry of Science and Technology allocated, within the National human Resources Training program, 10,000 scholarships at post-graduate level abroad and 30,000 within Brazil (Guimaraes, 1990).

example), privately through industrial firms funding, or through specialised government-funded technical institutions.

International experience¹⁸⁵ has shown positive results in countries where the general educational responsibility lies with the educational system, and specific industrial skills are learned through efficient on-the-job training, such as in Germany and Japan¹⁸⁶. This is a comparative advantage when compared with countries in which the formal education system provides both the general and specific skills, such as in Britain and United States. This is due to the system's ability to produce a wide range of skills with enough flexibility to respond to market demands. Market demands in the case of high technology firms usually fluctuate and are unpredictable. Other advantages for the on-the-job training schemes are that they facilitate re-training via job rotation (Dertouzos et al, op cit). Vocational education specially was efficient when it occurred in technical colleges¹⁸⁷. Not only was the labour market supplied with qualified personnel but also a cost benefit analysis showed that high return rates were obtained (around 20 %) using this system of vocational education: 'a careful analysis of the training of industrial workers revealed outstanding results for vocational education, as compared with academic education plus on-the-job training' (Castro, 1979:618).

Brazil, however, adopted a different strategy. Because of the failure of the public educational sector at primary and secondary levels to supply a skilled workforce, large private firms set up their own infrastructure and a private network offering this kind of service has emerged¹⁸⁸. The SENAI (acronym for the national centre for industrial learning) case is exemplary. Its efficiency rests on the fact that SENAI's strategies are tightly bound with the industrial sector. Because SENAI was set up by a group of industries of the metal-mechanical sector, representatives of those industries are members of SENAI's board. As a result, SENAI's graduates are quickly absorbed by the manufacturing sector. SENAI's effectiveness is higher than its US counterpart (Kempner and Castro, 1988).

¹⁸⁵ Dertouzos et al (op cit) carried out research in American manufacturing industries and Bessant and Grunt (op cit) for German and British cases.

¹⁸⁶ That is, specific training was performed on-the-job and complemented by formal technical education. This scheme was highly efficient.

¹⁸⁷ Callois (op cit), based on data from developing countries agree with this findings.

¹⁸⁸ Large and successful private firms are the ones that need more skilled personnel because they are usually exporters and their business is related to high technology products. Their sophisticated demands call for new skills to cope with the unpredictable market. That is, the use of new technology and new organisational methods require new production, programming, supervisory, managerial and maintenance skills (Senker, 1989).

However, it is important to note that SENAI's graduates usually go to the 'upper level' industries. On the one hand, they go to key industrial sectors, large and successful national firms or MNC branches. Those firms not only need them, due to their intensive use of high technology and new production methods, but also because they offer better wages than the average firm (Aragao, 1985). In this last aspect, the 'majority of firms' group are disadvantaged because of their low salaries policies. On the other hand, the majority of small and medium firms, that continue using outdated technology and organisational methods of production using workforces which are poorly educated and trained. For them, it is economically feasible to hire unskilled personnel. However, this contributes to staying in their stagnant position. The challenge then is to convince them to adopt modern organisational methods as a means of improving productivity and being able to improve wage levels at the same time.

Overall, SENAI's graduates seem to be sufficient in number to cover the demand for the skilled workforce of these upper level firms. In this sense SENAI's role is one of support. This is essential to the existence of an efficient ITC¹⁸⁹ that, in turn, supports the implementation of HC principles.

Outcomes of the vocational training system vary depending on the industrial sector involved. On the one hand, Smith's (1979) for example, in his study to determine the characteristics of Japanese technology transfer to Brazil, revealed that (i) education and skills of Brazilian employees, in general terms, were sufficient to enable them to absorb the technology; (ii) Brazilian management was good, but (iii) the level of education of Brazilian engineers seemed to be lacking. These findings met the above argument in the case of adequate supply of skilled personnel to upper class firms. On the other hand, study of the electronic industry, (Hewitt, 1988) pointed out that the scarcity of skilled labour was one of the major obstacles to the expansion of this industry. In the national computer industry for example, it seems to be that enterprises and training institutions were not able to organise themselves sufficiently to acquire the capacity to create skilled manpower.

Conclusions: Educational and Training System and the Human-centred perspective

A key factor in the implementation of HC principles is the existence of skilled manpower at all levels. Direct workers, supervisors, support staff and middle management need to possess

¹⁸⁹ Castro and Andrade (1990) suggest that the main issue behind the mismatch between supply and demand in public funded training institutions lies in the incentives and sanctions of the system. That is, public funded institutions do not need to change to survive and private institutions (like SENAI) are able to easily adapt to changing conditions because change is for their survival. They suggest that a reward system (eg tax relief incentives) should be set up for promoting training institutions effectiveness.

particular skills to cope with complex tasks. This is because the HC model puts humans and skills at the centre to pursue efficient work. Maintenance, co-ordination, detail scheduling, problem solving activities and interpreting SPC graphs are some key activities that shopfloor personnel need to be ready to execute. For this to occur, not only a highly skilled manpower is needed but also some pre-conditions are required at firm level: adequate rewards, career and a training system and some form of job stability.

In general, both primary and secondary education are lacking. As the above shows, both primary and secondary education has been neglected in order to support the tertiary level. An important reason behind this strategy, was that the state realised that, in the particular conditions existing in Brazil, it was not necessary to invest to re-produce part of the workforce to maintain the accumulation process (Cignoli, 1985). The tertiary level has been developed in a different way and wide differences exist between different areas. Excellence research centres co-exist with backward departments.

Due to the inability of the government to provide sufficient human resources for the growing industries in the 1970s, private capital set up their own training institutions to solve their immediate problems. These are successful in relative terms in selected industrial areas.

In the short term, despite the above, opportunity to provide a skilled workforce to manufacturing industries seems to be outside the formal educational system. Vocational technical training in technical colleges is, in relative terms, successful when funded and organised by private industrial institutions. This is a highly positive point to the implementation of HC principles because middle level technicians are crucial for the introduction of HC type productive systems (O'Siochru, 1990) and because successful national firms have a 'model' role that, can be applied to the majority of firms group¹⁹⁰. In the

¹⁹⁰ A feasible alternative for the majority of firms could be to apply the same strategies as those of upper class firms. That is, set up their own training institutions. It is recognised that their immediate needs, in terms of skills, are different from those 'upper class' industries, but an effective system of rewards and sanctions ought be set up parallel to assure its effectiveness.

In order to operate the above strategy, three points need to be addressed. First, the cost of training needs to be shared between state and private firms, which are the main direct beneficiaries. The tertiary education level, has shown good performance in selected areas which must be maintained as a means of assuring a pool of qualified scientific and technical staff to existing 'key industries' and successful national firms. However, participation of private firms, which receive those highly trained cadres, in the funding of research and graduate programs is marginal. In this case, the rigid bureaucratic structure of the formal educational system in which public universities exist, must be removed to allow private firms to negotiate their economic involvement.

Second, an adequate system of reward and sanctions (eg, tax relief schemes) at firm level is necessary to promote these kinds of initiatives. For this to occur, clear industry policy and labour legislation are needed. This is because the implementation of some organisational HC principles, such as improve rewards and set up career systems, are long term measures that promote better job conditions.

long term, the diffusion of HC principles will depend on a radical reform of both primary and secondary education. This will include not only providing adequate levels of financial resources but also reorganising its current centralised and bureaucratised structure.

5.3 CONCLUSIONS: MACRO INSTITUTIONAL CONDITIONS SUPPORTING AND CONSTRAINING THE IMPLEMENTATION OF HC PRINCIPLES

As suggested in previous sections, macro institutional factors in Brazil seem to be lacking. A great social, technological, infra-structural, financial and institutional effort is needed for supporting national industrial competitiveness. The existence of competitive firms (classified as 'successful national firms') nevertheless in different sectors, that successfully cope with technological, market and institutional uncertainties, suggest that firm competitiveness seems to be more related to particular technological and managerial competence, developed at firm level, than to the difficulty in overcoming structural weaknesses. This is a crucial point that sharply indicates that it is possible and feasible to introduce and diffuse of HC principles, even in weak macro institutional settings¹⁹¹.

This does not mean macro institutional factors are irrelevant. Rather, the degree of importance of macro factors for firm level competitiveness seems to depend on the national setting. In highly industrialised nations, in which a stable economic environment exists, a small change of one macro factor (eg growth rate or inflation) seems to affect, to a significant extent, firm level actions. The contrary occurs in semi-peripheral nations in which high economic, social and institutional instability exists. Because successful firms seem to know how to cope with macro uncertainties, any additional change in one macro factor will not affect, to a significant extent, the firm's *modus operandi*. Next, general macro institutional conditions that might support and constrain adopting HC principles at firm level are presented.

General macro institutional **factors supporting** HC principles implementation and diffusion in Brazil.

Third, the greatest barriers in contemporary Brazilian society are not only the lack of resources, but the lack of political will to re-direct resources to the welfare of the general population and to provide industry with skilled manpower. This is a matter that goes beyond education business and needs to be worked out at societal level.

¹⁹¹ This is a common research finding. The SBIC report and Nelson's (op cit) comparative study of national innovation systems, suggest a similar idea. This, does not mean contextual factors are irrelevant. Conversely they seem to be important in pushing the firm to take direct action to become competitive.

- (a) The existence of a relatively sophisticated and developed tertiary educational level in selected areas. This educational sector supplies highly trained university graduate technicians and scientists to the existing R & D network in the key industries and successful national firms.
- (b) While the general formal vocational system (performed at the neglected secondary school level) is lacking, privately funded and controlled vocational training systems work well enough to supply skilled technicians to successful national firms.
- (c) An indigenous technological capability has already been installed in several key industrial sectors. That is, the establishment of the capacity to 'learn to learn' to adapt organisational practices for constantly changing social, market and political conditions.
- (d) Despite the non-favourable industrial relations environment at general level, these firms have already developed their own mechanisms to overcome socio-political barriers. Relative job stability and specially intensive investment in training is a strong incentive for personnel not to leave the firm and, at the same time, gives greater bargaining power in acquiring another job. Wage differentiation is not necessarily a sound response to adverse industrial relations. At first sight, major obstacles do not exist to the implementation of the HC manufacturing practices at firm level. As commented earlier, successful firms are already applying selected dimensions of the human-centred approach.
- (e) The above mentioned firms are aware that traditional tayloristic/fordist work practices are no more efficient in coping with their market target requirements. A trusting environment is an indispensable requirement to use new production concepts. The favourable socio-political environment is not necessarily externally given but internally built. Again, matching worker motivation factors (eg rewards, responsibilities) with HC based organisational principles, is a supportive factor in those situations.
- (f) The low intensity of AMT existing in Brazilian firms, is a favourable factor to introduce and diffuse HC principles. The low level of inter and intra sphere integration of those technologies at plant level, far from being an obstacle to the introduction of HC principles, is a favourable factor. The reason being that it is easier to introduce HC principles in non, as yet, microelectronically integrated workplaces, than to try to overcome existing technocentric work practices embedded in those already electronically integrated. This is because the introduction of organisational (HC) principles precedes the introduction of computer-based technologies. Besides, the application of HC principles directly contributes to the realisation of second order

innovative activities (ie, piece-meal improvements in work and engineering processes), typical of semi-peripheral nations firms.

(g) Successful national firms play a 'model' role. This is an important factor that supports further diffusion of HC organisational principles. This is true in the case of direct supplier and local customers.

(h) Finally, the last factors that allow firms to use some elements of HC principles are, on the one hand, managerial capacity for searching and try new organisational forms able to cope with product demand requirements and the changing of capital/labour relations. While the former concerns technological issues such as the way to use equipment and the direction of R & D, the latter item is more closely related to the maintenance of stable internal socio-political environment. This managerial capacity exists but additional incentives and mechanisms are needed to awaken it.

The existing capacity of the Brazilian workforce, in terms of work intensity, is a favourable factor. As in other modern societies, industrialisation strategies and mechanism to implement them, possess more weight than cultural constraints. The Brazilian workforce is as hard working as any other. Domestic constraints however, at both macro and firm level, make productivity levels lower than the international standard. Brazilian workers are eager to be included in the economic benefits of better productivity and with the present level of unemployment, more or less work intensification is not an issue for the Brazilian manpower. They are already experiencing high levels of work intensity. What seems to be crucial are rewards and job conditions. The latter factors need to be reflected accurately in the valuation of skilled work.

In summary, a crucial question regarding HC principles application in Brazilian manufacturing is not whether it can be implemented because some elements are already being applied but, to what extent HC practices can be introduced successfully in Brazilian firms, which elements are the key ones and, to what degree successful firms using HC manufacturing practices can 'transfer' those practices to 'majority of firms' groups.

General macro institutional **factors constraining** HC principles implementation and diffusion are summarised as follows.

(a) At firm level, a major obstacle to the introduction of HC principles is the existing tayloristic/fordist models of production that are deeply embedded in the Brazilian manufacturing base. Roughly speaking, Brazil was and continues to be a mass producer nation

of semi-industrialised products. This, together with the political economy explanation of Brazilian industrialisation process, helps us to understand the wide spread of the taylorist/fordist model¹⁹². Management/worker relations are historically adversarial. The low wage policies pursued to achieve competitiveness together with the hierarchical paternalist relationship between management and workforce, further contributed to this situation. Thus, conservative management thinking (Smithz, 1982) for example, remains the important barrier to the application and diffusion of HC systems.

(b) Worker's organisations play a crucial role in addressing the above issues. Their input on ways of using and introducing new technology is key. However, organised labour seemed to be ineffective in coping with changing products and labour markets triggered off by globalisation/regionalization trends. In addition, there is also a widespread managerial attitude that is reluctant to have an open discussion with their employees regarding alternative ways of using new organisational arrangements or equipment.

(c) The lack of a consistent industrial policy, is an important factor that constrains any economic recovery and therefore, limits application of HC principles.

(d) A potential lack of skilled manpower may severely constrain the application and diffusion of HC organisational principles in the long term. This may be truer, in technologically advanced firms, if significant economic growth might continue¹⁹³.

(e) Additional negative factors that, need to be addressed in the short term, were spelled out by the SBIC study.

- stabilisation (economic and political)
- reforms: taxes, federation/state relations, welfare state, fiscal and financial
- recover financial and planing base to concretise investment in infra-structure, with special participation of the private capital.
- develop favourable means for productive investment in the long term.

Social and political support is needed to realise these reforms that aim competitive development. This involves real efforts to create policies that consider simultaneously competitiveness and equity. That is, new industrial relations, equitable distribution of productivity gains, employment creation and tackling the crises in the Educational system.

¹⁹² Examples of practices using what Lipietz (1987) called 'primitive taylorism' can be found in Hirata and Humphrey (1985). For cases of 'peripheral fordism' see Carvalho (1987), Humphrey (1982) and Zilvovicius (1987). For a discussion of the application of the taylorist model under contemporary conditions in Brazil, see Carvalho (1992).

¹⁹³ GNP was 4.20 %; in 1993, 5.67 % in 1994 and 10.5 % in the first three month of 1995. (Source: IBGE, Jornal Do Brasil, 05/19/95).

Two additional challenges are set up: re-building the state and re-structure the corporate system.

State re-building should be accompanied by the redefinition of goal, democratisation of its actions, renew regulatory mechanisms, reorganisation of the administrative apparatus and strength of the fiscal and tax system. In this form the State may perform, adequately, its new role of promoting competitiveness.

The corporate system re-structuring calls for deep changes in behaviour of industrialist and administrators. Firm's strategies for growth, capital-Labour relations and productive reorganisation should be oriented not only towards the achievement of competitiveness at firm level. It also towards external networks of suppliers and industrial associations linked to the financial sector. (Coutinho and Ferraz, 1994: 401-2)¹⁹⁴

Whether or not these macro factors really affect the introduction of HC principles is a key issue that will emerge from our empirical examination (Part II). Finally, it should be noted that because HC ideas are more a concept than rigid guide-lines, it needs to be built and adapted to the already existing 'industrial culture'. That is, further debate/discussion and the spread of information is needed more than specific investments in equipment or infrastructure.

¹⁹⁴ This is a free translation, from Portuguese, by the author.

PART II

HCMS IN BRAZIL: AN EXPLORATORY STUDY

CHAPTER 6

INTRODUCTION

As stated in the introductory Chapter, the key focus of this study is to determine if Brazilian firms are applying the HC model and if so, to explore how and to what extent this is happening. From this, two related research topics emerge: (i) how macro contextual conditions support or constrain the implementation of the HC model; and (ii) which are the main technical and organisational features of a 'tropicalized' HC model in Brazilian firms.

In order to address these questions, Case Studies were carried out in 10 Brazilian firms. The aim of the empirical study was to determine the form and level of human-centredness in these firms and to explore the factors affecting this. Such a study undertook an operationalisation of HC concepts, something that has not been effectively undertaken in the literature¹⁹⁵. The idea of cellular manufacturing has been used by the HC movement as the major basis for an integrated HC system (cf Badham and Schallock, 1991). This thesis takes up this notion and focuses on cellular manufacturing as a central expression of HC principles in socio-technical reorganisation. In order to further operationalise the concept of cellular manufacturing, two dimensions were used: the degree of 'horizontal' cellularisation and the level of 'vertical' cellularisation¹⁹⁶. An examination was then made of the patterns of HC horizontal and vertical development and their links with product, process and environmental factors identified in the literature as key influences of HC systems development.

Horizontal cellularisation represents the extent to which production operations are organised in a cell form. The extent of cellularisation in each plant is then related to 4 important manufacturing/product features in order to establish possible relations between them: manufacturing operations type; product type, product complexity and production scope; type of cell; and product profile in terms of design and manufacturability.

¹⁹⁵ For one, rare, attempt see Gordon and Krieger, (1990)

¹⁹⁶ In the methodological tool proposed here, the 'technical' dimension of the manufacturing system was omitted due to the lower levels of computer-based technology intensity existing in researched firms. It should be noted that the proposed tool to measure is only one way to approximate the HC criterion mentioned. Other indexes can be developed and serve as functional equivalents to the ones utilised.

The vertical dimension measures the 'depth' of human-centredness. This includes: how the control of operations and timing was re-arranged between production engineering staff and shopfloor personnel (supervisors and direct workers); the extent to which direct workers performed indirect manufacturing activities; and; the extent to which firm-wide reorganisation occurred (eg business units organised by customer or product; training, careers path and reward system changes). Three groups of indicators were developed to assess human-centredness in the vertical dimension, namely, direct manufacturing indicators that measure the control and timing of direct manufacturing activities as well as production and planning organisation issues; indirect manufacturing indicators, that assess the extent to which indirect manufacturing activities were transferred to direct workers; and wider organisational indicators that examine organisational structure at the wider firm level.

The examination of the vertical dimension is carried out in two stages. First, above set of indicators are discussed (see chapter 8). Second, the relations between shopfloor level and firm wide level indicators are discussed. Finally, a simultaneous examination of both horizontal and vertical indicators and the ensuing different degrees of human-centredness are distinguished (in chapter 9).

In order to examine the above factors as a group and not as isolated factors, the above mentioned indicators were displayed in a 'radar' scheme¹⁹⁷ (cf Stupp, 1987).

An examination is then made of the relationships between HC oriented firms and product/market (business), design and manufacturing strategies in chapter 9. This is made in order to test Sorge and Streeck's (1988) arguments that HC type organisations are more suited to specific industries (ie the engineering one) in core European nations.

¹⁹⁷ This scheme allows us to focus more on the synthesis than on the analysis of individual variables. In this way we can examine the extent of work structure reform at shopfloor and organisational reform simultaneously. In other words, it represents actual *organisational configurations* which, in turns, reflects our theoretical framework. This methodology will facilitate the differentiation of HC organisational structures from the other organisational structures.

6.1 GENERAL FEATURES OF RESEARCHED FIRMS¹⁹⁸

Ten researched firms operating 14 industrial plants¹⁹⁹ were studied (see Exhibit 6.1). They belong to the following industries: (i) The non-electrical machinery (ISIC 382); (ii) the electrical machinery (ISIC 383); and (iii) the transport equipment (ISIC 384)²⁰⁰.

A large proportion of the researched firms are metal-mechanical. That is, capital equipment and automobile parts manufacturers which deal with metal-cutting productive activities. The significant amount of tacit skills needed to perform these metal-cutting related tasks was the main reason for choosing discrete metal-cutting manufacturers. Among the capital equipment producers, one firm possesses both electro/electronic and metal-cutting activities as their dominant manufacturing operations. Among the automobile suppliers, one firm, the plastic parts producer, does not possess metal cutting production tasks as the bulk of their manufacturing operation. Nevertheless, as in the case of metal-cutting producers, batch production (ie discrete manufacturing) is a common feature and a great degree of tacit knowledge is needed to perform operations due to the use of low/medium levels of programmable manufacturing equipment. An additional characteristic was the advanced human resources strategies currently being implemented in the majority of the firms in the study. This non homogeneous sample was chosen because it will allow us to test if the HC model is feasible to be implemented in other firms beyond the engineering industry.

The majority of industries considered in the sample were representative of the engineering sector. This sector constitutes, in Brazil, a sizeable share of manufacturing value added (36 % circa 1980). This figure is significant when compared to 23 % in Korea, 21 % in Mexico, 43 % in Sweden and 39 % in UK (Edquist and Jacobsson, 1988:152). Exhibit 6.1 outlines the main features of all the firms selected for examination.

The sample was evenly distributed in terms of *ownership*. From a total of 10 firms, half were Brazilian-owned and half were subsidiaries of foreign multinationals. The mix of foreign owned firms selected was heterogeneous. Of these, one was Japanese owned, one by a US

¹⁹⁸ For details regarding criteria for the selection of sites and methodological issues see Chapter 2.

¹⁹⁹ Because of practical reasons, 'emb' was divided in three plants, emb1, emb2 and emb3. Each had a distinctive layout and production organisation form. 'wor' was also divided in two plants. Each had a very different layout and production management. This differentiation allowed us to observe how different work and managerial strategies might be applied in the same firm.

²⁰⁰ ISIC : International standard industrial classification

Firm	Industrial Sector and ISIC (a)	Type of manufactur. operations	Principal Products	Ownership	Firms size (by number employees)	Size of production batch (b)	Market strategy
YAN	Capital equipment (ISIC 382)	Metal-mechanical	agricultural machinery; engines	Japanese	400	1-10 (10%) 11-100 (90%)	domestic:70 % overseas:30 %
WOR	Capital equipment (ISIC 382)	Metal-mechanical	pumps; compressors	USA: 51 % Germany: 49 %	400	1-10 (98 %)	domestic: 90 % overseas: 10 %
VIL	Capital equipment (382)	Metal-mechanical	lifts; electrical stairs	Brazilian	n.a.	11-100 (80 %)	domestic: 80 % overseas: 20 %
EMB	Capital equipment (384)	metal-mechanical	regional passenger aircraft	85 % Brazilian	5.873	1-10 (100 %)	domestic: 32 % overseas: 68 %
WEG	Capital equipment (383)	electro-metal-mechanic	AD/DC electrical motors	Brazilian	4.364	1-10 (30 %) 11-100 (50 %)	domestic: 80 % overseas:20 %
ML	automobile supplier (384)	metal-mechanical	engine pistons, cylinders,rings.	Brazilian	4.877	501-2000 (15%) + 2000 (85 %)	domestic: 30 % overseas: 70 %
CLA	automobile supplier (384)	metal-mechanic	mechanical transmission; power shift; axles.	USA	2.700	1-10 (14 %) 11-100 (42%) 100-500 (32%)	domestic: 80 % overseas:20 %
WAB	automobile supplier (384)	metal-mechanic	brake system	USA Germany	340	11-100 (80 %)	domestic: 80 % overseas: 20%
SIE	automobile supplier (ISIC 383)	electro-electronic	relays, senders, control electric boards	Germany	572	101-500 (60 %) 500-2000 (20%)	domestic: 100 %
OSA	automobile supplier (384)	plastic parts	bumps, panels, arm rest.	Brazilian	1.176	502-2000 (28 %) +2000 (46 %)	domestic 100 %

(a): ISIC : International Standard Industrial Classification

(b) : Batch size in number of units; number inside parenthesis represents % of productive activities.

EXHIBIT 6.1: General features of researched firms

company, one German as well as two joint ventures between American and German firms. This heterogeneity would help to explain whether or not a firm's national background influences the organisational design strategy applied.

Location. Because the degree of organisation and the political power of trade unions varies across regions and within regions, a differentiation has been made between city and rural based enterprises. Four firms were located in cities and six were located inland. In the former, trade union activity is generally strong and union membership is relatively high. Conversely, in the latter, union pressure is weak as union activities are not very well organised. Because advanced forms of production and work organisation call for high levels of shopfloor personnel co-operation, (which in turn, is related to the degree of influence and the position of local unions), location factors seem to be relevant for appreciating the extent of HC principles implementation. All firms were located in the most industrialised States: Sao Paulo, Rio de Janeiro and Santa Catarina.

In terms of *size*²⁰¹ the sample is also heterogeneous. Five firms are large, three are small, one is medium sized and one very large. Because the aim of the research was to analyse the most advanced form of HC organisational arrangements, the predominance of large firms in the sample is not surprising. They usually possess enough motivation, resources, knowledge and market pressures to be innovative.

Ownership and Market Strategy

In general terms, national firms were more likely to target export markets than foreign owned firms. Two clear patterns were found. First, in the majority of sampled firms (8 out of 10), more than 85 % of their output was oriented to domestic markets. Second, only a minority of firms (2 out of 10) had more than 70 % of their output oriented to foreign markets. Of the 8 domestic market oriented firms, 6 were foreign-owned and two nationally owned. Conversely, the only two export-oriented firms in the sample were Brazilian owned. It is important to note that foreign firms usually possess enough expertise to reach foreign markets but their strategy, in Brazil, seemed to be directed towards domestic demand only.

Despite the small size of the sample, these findings support what other studies (cf Reiss, 1980; World Bank, 1983) have already pointed out. Firstly, the domestic market is the main source of economic growth and economic activity in Brazil²⁰². Secondly, export-oriented firms are

²⁰¹ Size is defined, in this study, in function of number of employees.

²⁰² After 1991, with the implementation of policies to open the economy, this picture seems to be changing. However, it is still too early to made any conclusive statement, regarding pace and direction of openness.

not typical of their sectors. They are more capital and skill intensive than non-export-oriented firms (Silber, 1983).

In terms of their contribution to develop local technological capabilities, our case studies point out that the contribution of foreign and national firms differ greatly. In the former, generally, the design stage is conducted overseas in the parent company leaving just small adjustments to be made locally in order to adapt design specifications to existing machinery. In the latter, usually both design and manufacturing processes are made in-house (cf Sercovich, op cit). This pattern, however, does not mean that engineering departments of multinational firms are not important. Out of five foreign-owned firms, two firms (cla and wor) developed new products and/or productive processes that were exported to their parent companies to be used world-wide. However, the contribution made by Brazilian-owned firms is far larger. The level of value-added made in-house, is larger than that of foreign owned firms.

Batch Size Profile

The firms in this study had a wide range of batch sizes. Lot size ranged from very low (from 1 to 10 equal parts) to very high volume (more than 2000 identical parts). Despite a significant proportion of researched firms (4 out of 10) being concentrated in the 11 to 100 bracket, the remaining firms were evenly distributed in other batch size brackets. As expected, capital equipment industries produced in small batches, but automobile suppliers had high production runs. Moreover, the range of firms' batch sizes is useful for the present research purposes as batch size constitutes an important indicator of different productive systems with their associate manufacturing goals and constraints. In this sense, a variety of researched firms provide an opportunity to appreciate appropriateness of the HC model under different technical needs and market pressures.

Customisation scope

8 out of 10 firms had a high degree of customisation. That is, more than 70 % of their output was customised. It is not surprising that capital equipment producers were the ones that had a high degree of customisation. In general terms, the customisation profile of the researched firms coincides with industrialised nations trends toward increasing customisation as a strategy to improve competitiveness.

Firm Output Profile

Item	Number of basic products manufactured (units)	Proportion of standardised products manufactured (average %)	Proportion of customised products manufactured (average %)	In-house Value-added (average %)
Firm				
osa	4	0	100	50
sie	6	0	100	n.a.
wab	6	80	20	n.a.
vil	2	0	100	60
yan	4	70	30	40
ml	2	0	100	75
weg	2	65	35	65
cla	3	0	100	60
emb	3	0	100	34
wor	2	10	90	n.a.

Exhibit 6.2 Firm output profile

Exhibit 6.2 displays the main characteristics of the product range strategy. First, of the total of 10 firms in the sample, the scope of products is narrow (4 produce 2 products, 2 produce 3 products, 2 produce 4 products and 2 produce 6 basic products²⁰³).

Second, 7 out of the 10 firms produced customised output only, while 3 produced standardised output. The present sample might possess some bias towards customised-oriented firms. In customised-oriented enterprises of the sample, however, the range of different models available within each basic product is virtually unlimited, though a significant amount of similarity, in design and manufacturing terms, might exist.

Third, the average of value-added inside the firms is high - between 35 and 75 % - 5 firms possessed an average of in-house value-added of 62 %. These figures suggest a high degree of verticalization. An outstanding example was a firm which buys only raw material and

²⁰³ That is, products which are totally different from each other in design and process manufacturing terms.

manufactures the whole product in-house or through firms belonging to the same group. The most common reason given by managers when deciding on a 'make' or 'buy' strategy, was the lack of reliable suppliers for quality, delivery time or technology requirements. High technology content products usually require high quality raw materials, parts and components.

The majority of researched firms generally pursue a strategy of concentrating on a narrow range of different products but within each item they offer customised models. The final aim is the search for higher product differentiation. Increased product differentiation may be obtained, however, not only from the achievement of different product strategies in terms of quality, price and product performance, but also from other factors such as post-sales service and warranty terms, among others. The fact that several firms were suppliers to the automobile industry explains the high degree of customisation. That is, their products were highly specific and of high technological content.

CHAPTER 7

THE HORIZONTAL DIMENSION

The extent of horizontal cellularisation requires the examination of the physical extent to which a cellular layout has been introduced in firms. That is, the proportion of shopfloor manufacturing activities throughout the plant which is arranged in cell configuration. After assessing the extent of cellularisation, a contingency argument is used to search for any relationship existing between the extent of horizontal cellularisation and product customisation feasibility, batch size and cell type. This analysis is important because it will allow us to observe relationships between the horizontal component of human-centredness and key product related items. The key finding of this chapter is that the extent of horizontal cellularisation is independent of: (i) process technology; (ii) type of cell; (iii) product customisation feasibility; and (iv) batch size. This is important for HC model diffusion since points out that key product related features do not prevent applying cellular manufacturing, a fundamental stone to develop HC manufacturing systems.

Thus, the first section determines the extent of cellularisation and relates it with type of manufacturing process²⁰⁴. This analysis is relevant as it provides clues as to whether or not the type of manufacturing process supports or not the cellularisation process. The second section analyses if the achieved extent of cellularisation is related to other groups of key product features. Namely, product type, product complexity and production scope. The aim is to throw some light on the supporting or constraining nature of these product features on implementing manufacturing cells. The third section compares the extent of cellularisation to cell type. This examination provides insights into the relationship between type of cell used and extent of cellularisation achieved. The last section examines the potential relation between the achieved extent of cellularisation and batch size. The goal is to acquire knowledge about the supporting or constraining features of batch size over the cellularisation process.

²⁰⁴ Three types of manufacturing process exists: machining, assembly and molecular transformation process.

7.1 THE EXTENT OF HORIZONTAL CELLULARISATION

Exhibit 7.1 shows that, of the 10 firms, 7 applied cell concepts to a significant extent, (ie, to more than 62 % of their manufacturing operations). Only two of the ten firms applied it to a small extent (ie less than 25 % of their manufacturing operations). It can also be observed that the cell concept was not only applied to machining, but also to assembly and molecular transformation manufacturing processes²⁰⁵. This is important for the diffusion of HC principles, as cellular manufacturing is a key building block of human-centredness.

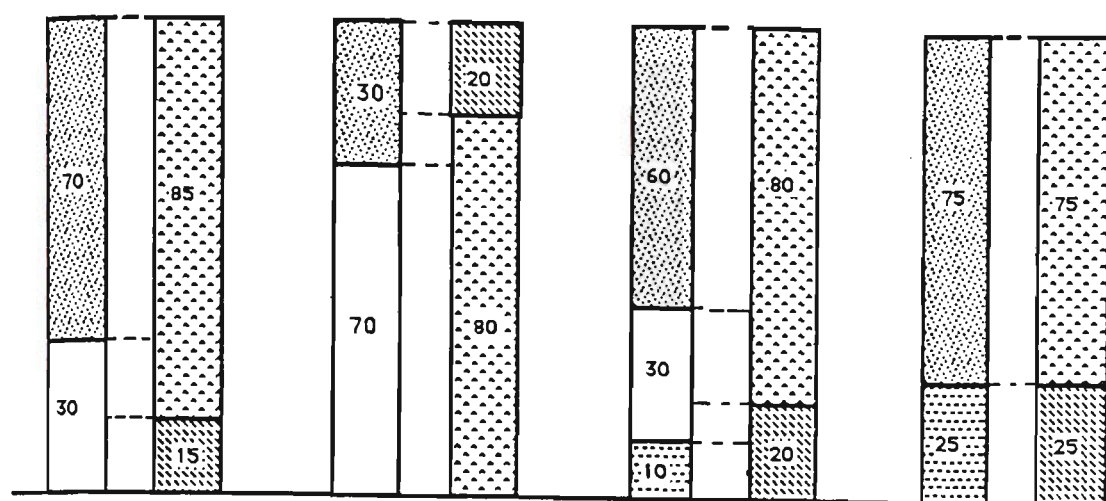
7.2 PRODUCT CUSTOMISATION FEASIBILITY AND THE HORIZONTAL DIMENSION

This section is directed towards the search for relations between some key product related features (product type, product complexity and production scope), called Product Customisation Feasibility (PCF), and their role in facilitating or harnessing the extent of the cellularisation process achieved. PCF refers to the degree of ease which a product can be customised to obtain a 'new' model or product. The evidence shown supports the argument that the achieved extent of cellularisation is little related to product type, product complexity and production scope (ie PCF).

PCF is partly a function of the nature of the product and partly a social choice. On the one hand, it depends on market targets and the design technological trajectory followed which, in turn, is a function of the management strategic choices made to decide specific market targets and associated design trajectories.

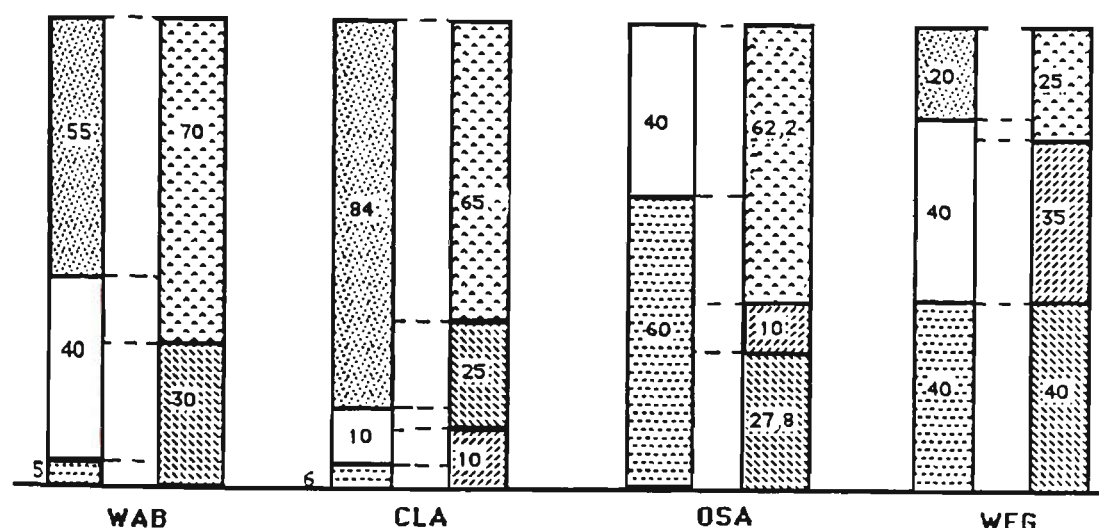
On the other hand, it is important to remark upon the socially constructed nature of 'technical' choices made by management which is harnessed by a series of factors that go beyond managerial control. In the case of product and market choice, for example, management not only considers technical constraints and advantages, but also other subtle, but no less

²⁰⁵ Two firms (electro-electronic auto component and plastic parts auto producers) which do not fit well into the metal-mechanical category, possess a high level of cellularisation. These firms illustrate the feasibility of applying cell concepts in manufacturing operations other than machining. The case of plastic parts auto producers is especially illustrative. In this firm, 40 % of manufacturing operations are assembly operations and 60 % are molecular transformation. Cell concepts were successfully applied in 37 % of molecular transformation activities. In the case of the electro-electronic auto OEM for example, 70 % of their manufacturing operations were assembly activities to which cell concepts were applied.



MANUFACTURING OPERATIONS (%)

- machining
- assembly
- molecular transformation



PRODUCTION ORGANISATION (%)

- cells
- by product
- by process

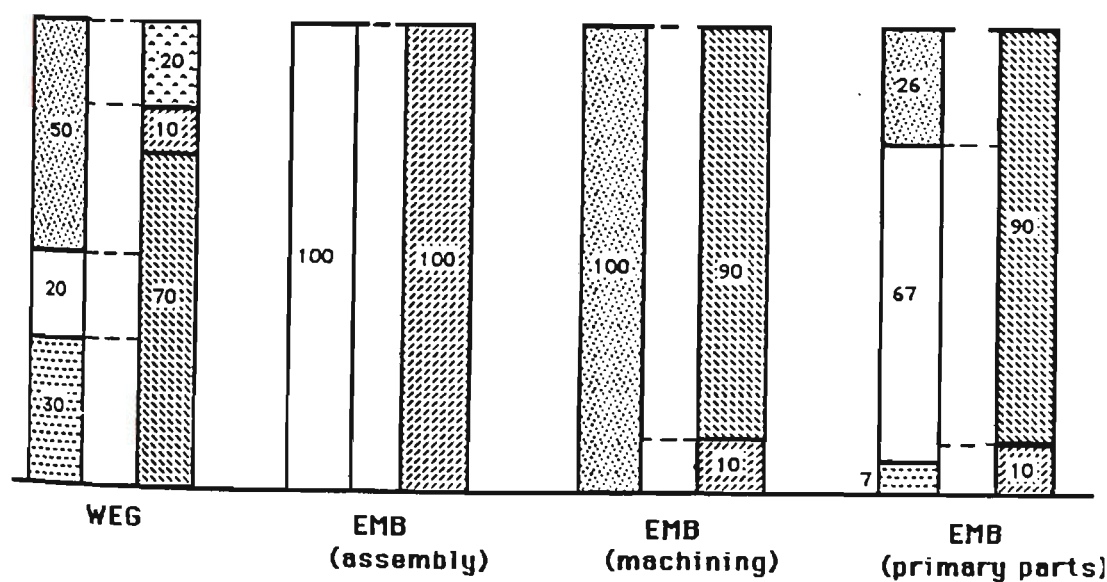


EXHIBIT 7.1: HORIZONTAL CELLULARISATION EXTEND

important, social factors that affect the final choice. Examples of such social factors might be the career and power position of the decision makers; in subsequent stages of the project, machine-buying; implementation of technology and routine operations. Extra firm events, such as the existence or not of government loans for investment in specific technical areas, or markets (eg existence of government export incentives) or workers' organisations positions regarding firm operations, all these would eventually further narrow the options available to management to decide on which product is to be manufactured and to which market that product must be directed.

Therefore, PCF can not be considered a simple 'technical' choice. Product and market target choices, made in the past, affect strategic decisions that need to be taken in the present. In some cases, product customisation related to past choices might support strategic decisions. In others, they might constrain the present range of options to restructure products and manufacturing activities. In other words, a firm's products will possess features which support or constrain rapid changes in order to customise them. While re-designing products within the original design technological trajectory can help achieve better customisation feasibility, often radical innovations along a new technological trajectory are required to optimise PCF. The choice to do this is a managerial prerogative.

In addition, both design and manufacturing customisation feasibility are strongly connected with the nature of the product involved in terms of its functional role. Products such as automobile panels, in which external appearance is essential, are usually easier to customise than products which perform a key functional role, such as, engine pistons or brake cylinders. In the former, small changes in product design would result in 'new models' or even products without endangering product performance. In the latter case, small design and manufacturing changes need to be fully tested due to their direct interference in product performance. Mechanical, electrical, electronic and/or hydraulic product performance in the latter case are crucial items to achieve competitiveness.

PCF, it is argued here, is a function of (i) product type; (ii) product complexity; and (iii) product scope.

Product type refers to the extent product features facilitate or constrain the customisation process. Burbidge (1979) found two types of manufacturing transformation systems in the engineering industry. He called them explosive and implosive. In the former a large number of materials are used to make a small number of assembled products. In the latter, a small number of materials are used to make a large number of components sold as a large number of components or subassemblies. For the purposes here, explosive transformation systems

constrain PCF and implosive ones favour or support PCF.

In the researched firms, the paradigmatic case of the lift producer is illustrative. Finished lifts are all different. That is, they need to be 100 percent customised according to the functional requirements of customer and the physical dimensions of the building where it will be installed. However, all lifts possess the same basic components, doors, cabins, electrical control boards, engine rails etc., from which some technological parts (eg engines capacity) and final assembly components (eg interior decoration) are changed to meet customer's demands. In short, the 'nature' of this product favours PCF.

Conversely, in the case of a automobile part manufacturer, derivation of new models is highly complex because of the nature of the product. Because produced parts play a key functional role in the performance of the final product, manufactured parts call for high precision. Then, even small modifications to the original design need to be fully tested before its production. Moreover, customised products need, in the majority of cases, the re-design of a significant part of existing products. Therefore, from the same basic parts a narrow variety of different products can be derived. The latter is true more in design than in manufacturing terms. This type of product constrains PCF.

Product complexity is the inherent degree of complexity associated with each product in order to derive a new model. The more complex the product, the more difficult its design and manufacturing operations. Both design complexity and manufacturing complexity indicators compound product complexity.

Production scope is the current range of different models and products possessed by the firm. This item is strongly related to a firm's market strategies but has little relationship to product features. A higher production scope implies a better market position for a firm. However, a high production scope (ie a high range of different products with a high number of models within each product) also implies a more complex production operations management due to the high number of different (but similar) parts to be processed. Therefore, a higher production scope seems to constrain PCF. Exhibit 7.2 summarises empirical data.

Exhibit 7.3 shows the relationship between the current degree of cellularisation achieved (or cell extent) and PCF. It is clear from Exhibit 7.3 that the degree of cellularisation is little related to PCF. This suggests that a firm's PCF may be more related to building capability at both design and manufacturing spheres, than to product related features such as product complexity, type and scope. Therefore, experience, skills, technology used, physical infrastructure, and organisational deployment, such as design for manufacturing techniques as

Firm	Product Type	Production Scope	Product Complexity (design)	Product Complexity (manufact)	Product feasibility (design)	Product Feasibility (manufact)
osa	favours	4 products 100 models	medium/ high	medium	high	high
sie	favours	6 products 250 models	medium	low	high	high
wab	not favours	4 products 100 models	high	high	low	low
vil	favours	2 products (100 % customis.)	high	high	very high	very high
yan	not favours	4 products 11 models	high	high	low	low/ medium
ml	favour (medium)	2 products 8 models (100% customis.)	high	high	low/ medium	low
weg	favour (medium)	2 products 50 models	high	high	low	low
cla	not favours	3 products 4 models	high	high	low	medium
emb	not favours	3 products 3 models	high	high	low	low
wor	favours (medium)	2 products (100% customis.)	high	high	low	low

EXHIBIT 7.2: Product Customisation Feasibility

PRODUCT CUSTOMISATION
FEASIBILITY

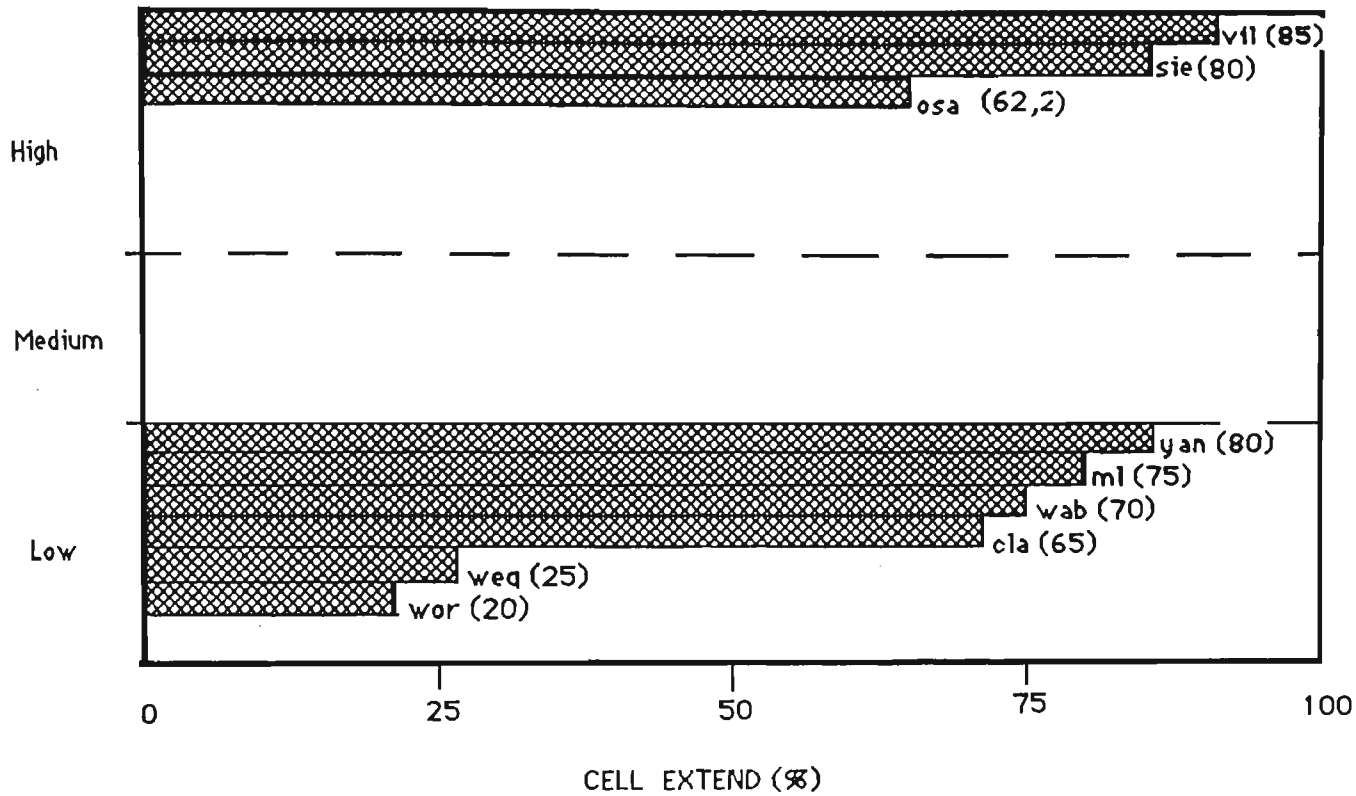


EXHIBIT 7.3: Horizontal Cellularisation and Product Customisation Feasibility

well as personnel commitment and motivation, in both design and manufacturing spheres, seem to be the key factors to build PCF capability, but the former factors seem to be independent of the extent of cellularisation achieved²⁰⁶. A tentative explanation as to why PCF is little related to the degree of cellularisation might be that, in our sampled firms, PCF was part of the firm's design strategy and the cellularisation extent was part of a manufacturing strategy. Both design and manufacturing strategies, however, seemed to possess different weights resulting in non congruency between them.

The above findings are important for the HC theory as they illustrate that the degree of horizontal cellularisation extent seems to be independent from product type, product complexity and production scope (or PCF). This implies that the implementation of cellular layouts, that in turn favours the use of HC organisational principles, are not limited by any technical constraint of the product. Rather, it is a managerial prerogative.

7.3 CELL TYPE AND THE HORIZONTAL DIMENSION

There are two the arguments developed in this section. Firstly a high range of variations might exist in cell type terms, despite similar product related conditions such as PCF. Firms combine theoretical typologies of cell in different ways depending on: technical factors (eg product type and PCF); labour (eg worker attitudes to new lay-outs); management limitations; top management support to boost the cellularisation process, and/or middle management support or hindrance of the implementation of these organisational changes. Different types of cell combined within the same plant were found in sampled firms. Secondly, there seems to be little connection between the achieved extent of cellularisation and type of cell used.

Cell type is an important research question because of the existing connection between the level of interdependence and degree of self-regulation that a work group might possess. The latter, as mentioned in chapter 1, is an important feature of HC work. Slocum and Sims (1980) and Thompson (1983) for example, suggested that 'pooled' interdependence between work units favours the application of self-regulating work groups, while sequential interdependence constrains the work group with self-regulation features. In the same way, because the level of interdependence in a pure cell is low, the implication is that the pure cell

²⁰⁶

Cases such as 'osa' and 'vil' show the importance of a firm's capability to obtain high design and manufacturing product feasibility. In these two cases, despite possessing high/medium levels of product complexity, firms have achieved high product feasibility in design and manufacturing terms. That achievement was not only due to their product type, which favours customisation, but is mainly due to their acquired design and manufacturing capabilities. Thus, it seems that PCF is only slightly related to product complexity.

supports work groups with high self-regulation.

The use of sequential cells with low levels of inventories between them, means higher interdependency between cell. This produces negative impacts in terms of the extent of work group autonomy (Susman, 1990; Klein, 1989) as their performance is paced by the next cell. This is one feature that helps to explain why Japanese manufacturing techniques lead to low levels of work autonomy compared with Western work settings (Lincoln and Kalleberg, 1990). At the same time, this is only one key work feature that differentiates Japanese techniques from HC perspectives. That is, while in the former a low level of work group autonomy exists due to the high interdependency level, in the latter, low interdependence allows time for problem-solving, co-ordination and planning activities during normal working hours. In the Japanese model, small group activities usually occur out of normal working hours.

Four types of cell were observed during the empirical field study. These different types of cell seem to be associated to the a current stage of cell development. While the former feature has already been explained, the second one needs further explanation. Stages of cell development are related to the age of the cell and on whether or not the cellularisation process continued to be developed. A specific type of cell corresponds to each stage of cell development. These stages are illustrated in the Exhibit below.

Stage of cell development	Type of cell
I.	non-sequential
II.	sequential
III.	pooled
IV.	pure

Exhibit 7.4 : Cell Development Stages

The stages of cell development can be from relatively simple configurations, such as non-sequential types, to complex configurations such as pooled or sequential arrangements. While the 'pure cell ideal' is the final goal, different factors such as product type, technical capability and, especially, middle management willingness, affect the evolution of the cellularization process. Depending on these factors, different firms are in different cellularisation stages. In the present sub-section, however, only those cell types found in researched firms are referred to.

(i) *Non-sequential cell* is the term used to describe the type of cell in which it was not possible to incorporate all productive operations to get a 'pure' cell type. There are many reasons for

this cell type's existence. Three were considered to be significant. Firstly, the cellularization process there has not reached maturity; secondly, product types are highly complex in terms of the large amount of different parts needed and their associated different processes. Therefore, some processes need to be done outside the cell. This, in turn, is related to both product scope and degree of sophistication achieved during 'grouping' of parts to get 'families'. The more precise the grouping of parts, the narrower the product scope and the easier the cellularisation process and vice-versa. Thirdly, the interdependence level among and between cell and functionally arranged manufacturing areas, depend on the existing buffer levels between cell and functional areas. Because synchronised transport to and from functional areas is very unlikely to occur, a significant buffer volume is formed. As a consequence of this, interrupted cell usually possess low interdependence levels.

(ii) *Sequential cells* are those in which one particular cell's input is the previous one's output. In order for a second cell to initiate manufacturing activities, the previous one has to finish its share of the work. The level of interdependence between cell arranged in sequential layout is a function of existing buffer levels amongst them. Buffers between cells, in this case, are formed mainly because of difficulties (ie economic unfeasibility) in balancing the material flow amongst the cell.

(iii) *Pooled cells* are those whose input comes from the cell that supplies basic parts to a group of cell. Sequential interdependence exists between the basic cell (which supplies basic parts) and each of the other ones. The level of interdependence again is a function of buffer levels existing between the basic cell and the others. Interdependence levels among other cells is low because, they usually produce different finished models. In these cases, the buffer size in each final cell varies accordingly to each cell's WIP.

(iv) *Pure cells* are those in which it has been possible to incorporate all productive activities necessary to produce a finished part into a single cell. In this form, the final product is 100 percent ready to be assembled. This type represents the most advanced manufacturing cell arrangement. Theoretically, pure cell seem to support, to a significant extent, the improvement of the manufacturing process. Co-ordination of production flow between different cells (whatever their type) is a key element, which determines, to a significant extent, WIP and buffers, which are key determinants of any productivity measure. As co-ordination levels are minimised, this arrangement potentially brings significant pay-outs of loosely-coupled work structures.

As mentioned above the product type, product design and manufacturing feasibility, partially explain the cellularisation process. From the total of researched firms, for example, only 'ml'

was able to set up pure cell. There are two reasons for this. First, they started to implement manufacturing cells in 1987. This means they acquired reasonable experience in cellularisation. Second, the nature of their product supports further cellularisation processes in the 'pure' mode. For example, 'ml' produces a set of internal mechanical parts of engines. Those parts function jointly but their manufacturing entails very different processes. This characteristic of parts produced allows a clear physical separation of different parts produced which form the required final part. The 'ml' shopfloor is totally organised as mini-plants, each one producing a total part. Each cell produces completely a defined part which conforms to the final component. Nevertheless, it was a top management decision to support the restructure of the whole plant in business units along factory-within-a-factory concepts that made possible the achievement of a high degree of cellularisation. It seems that, without the latter, the expansion of the cellularisation process would not go further, even under favourable product related conditions.

The examination of empirical evidence regarding cell types points to three important issues. First, the cell type applied is weakly linked to PCF and strongly connected to the cell age and management willingness to continue cell improvement towards the 'pure' type in the long term.

Second, the achievement of an advanced stage of cell development (eg pure type), however, while it is an allowing factor that supports human-centredness, it does not automatically mean a high degree of human-centredness. It was noted in the field that different 'bufferisation' configurations might exist both inside the cell and inter-cell (independent of the type of cell used). The latter is a key factor in determining the degree of inter-cell interdependency. The degree of cell interdependency, in turn, is a key component of the HC concept that explains, to a significant extent, the degree of human-centredness. High cell interdependency, for example, means high work synchronisation, which constrains the achievement of higher levels of human centredness (see chapter 4 for details).

Third, empirical data suggests that there is no direct linkage between the types of cell used and the extent of cellularisation (see Exhibit 7.5).

These findings are important for an understanding of the application of HC principles. If, as the data suggested, the extent of cellularisation is not dependent upon cell type and since cellularisation can be readily aligned to HC principles, the implementation of HC principles is not constrained by adherence to a particular cell type.

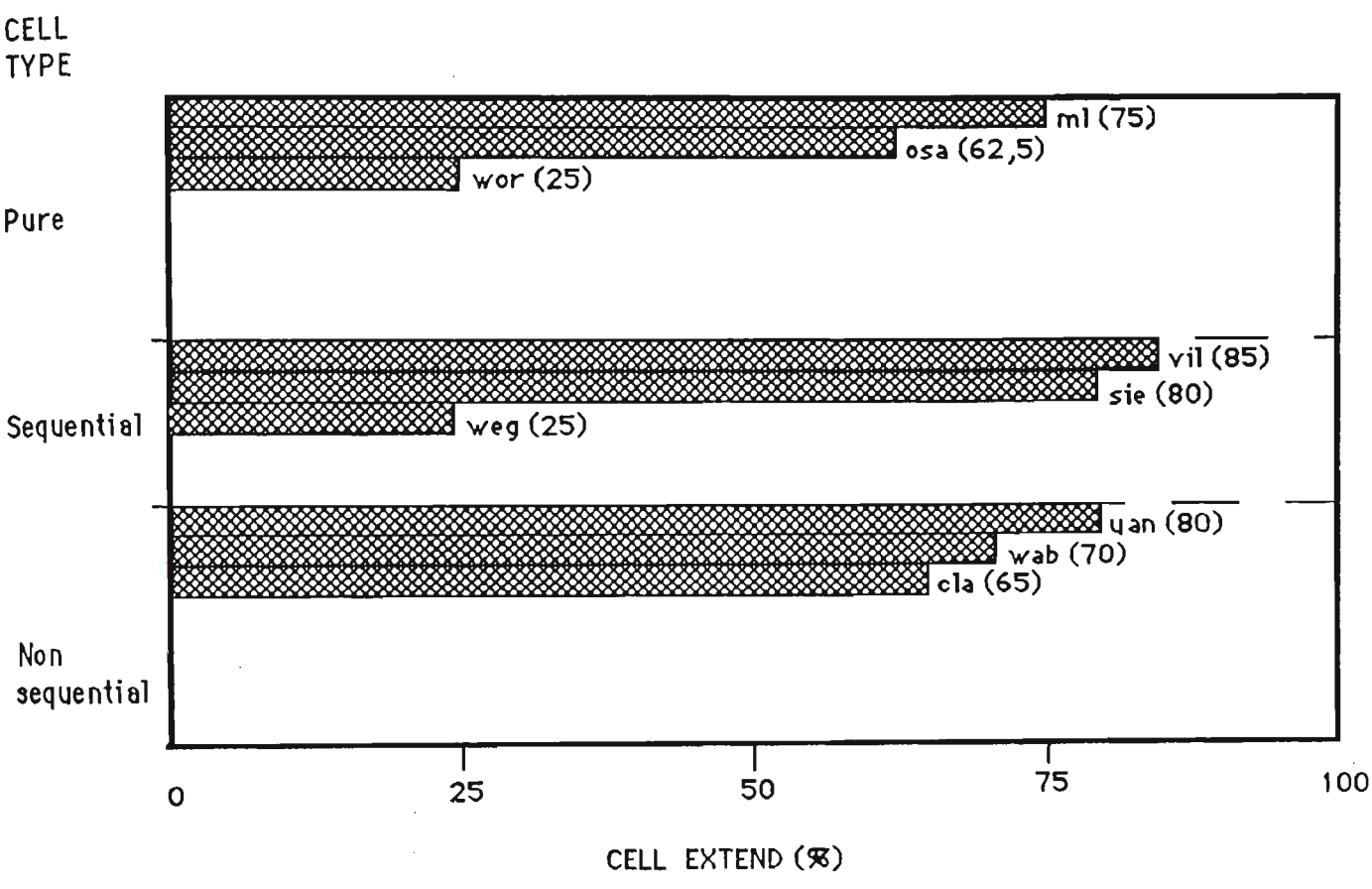


EXHIBIT 7.5: Horizontal cellularisation extent and cell type

7.4 BATCH SIZE AND HORIZONTAL CELLULARISATION

This section displays empirical evidence that suggests that an independent relationship exists between the extent of cellularisation and batch size. Although early sociological studies (eg Woodward, 1967) have identified batch size as one key variable in explaining manufacturing operations typology, the findings here suggest that there is only a weak connection between batch size and the extent of cellularisation. Exhibit 7.6 shows that diverse degrees of cellularisation were found, either in small, medium or large batch size firms. Therefore, the application of HC principles is not constrained by batch size. It should be noted that these findings are congruent with the literature on cell (cf Burbridge, *op cit*). Findings bring important implications for the implementation and diffusion of HC principles.

(i) Because the extent of cellularization is weakly linked with product/market features (PCF), the type of cell and batch size, it is possible to assume that the application of HC principles might be proceed independently of these factors.

(ii) The above finding is positive for the application and diffusion of HC principles, as the weak relationships between the extent of horizontal cellularization, cell type and batch size, implies it is feasible to use the cell concept independently of industry type. This is relevant, because the HC literature contends that only particular industry types are capable of successfully implementing HC concepts due to specific product and market factors, such as production of highly customised products in small batches. Nevertheless, it is too early to conclude that examined product related features are the only crucial factors supporting HC principles application and diffusion, as the cellularization concept used here does not give information about the quality of work inside the cell. This point is further developed in chapter 9.

(iii) Firms which applied cell concepts to their manufacturing activities, did so as a core part of a pro-active firm strategy to improve their competitiveness level²⁰⁷. This strategy, however, was not necessarily integrated to product types, batch size and product customisation

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Competitiveness can be understood in terms of: (i) low manufacturing costs; (ii) better product quality; and (iii) enough manpower, production planning, production operations and ancillary manufacturing activities flexibility to achieve desired due dates and mix of products.

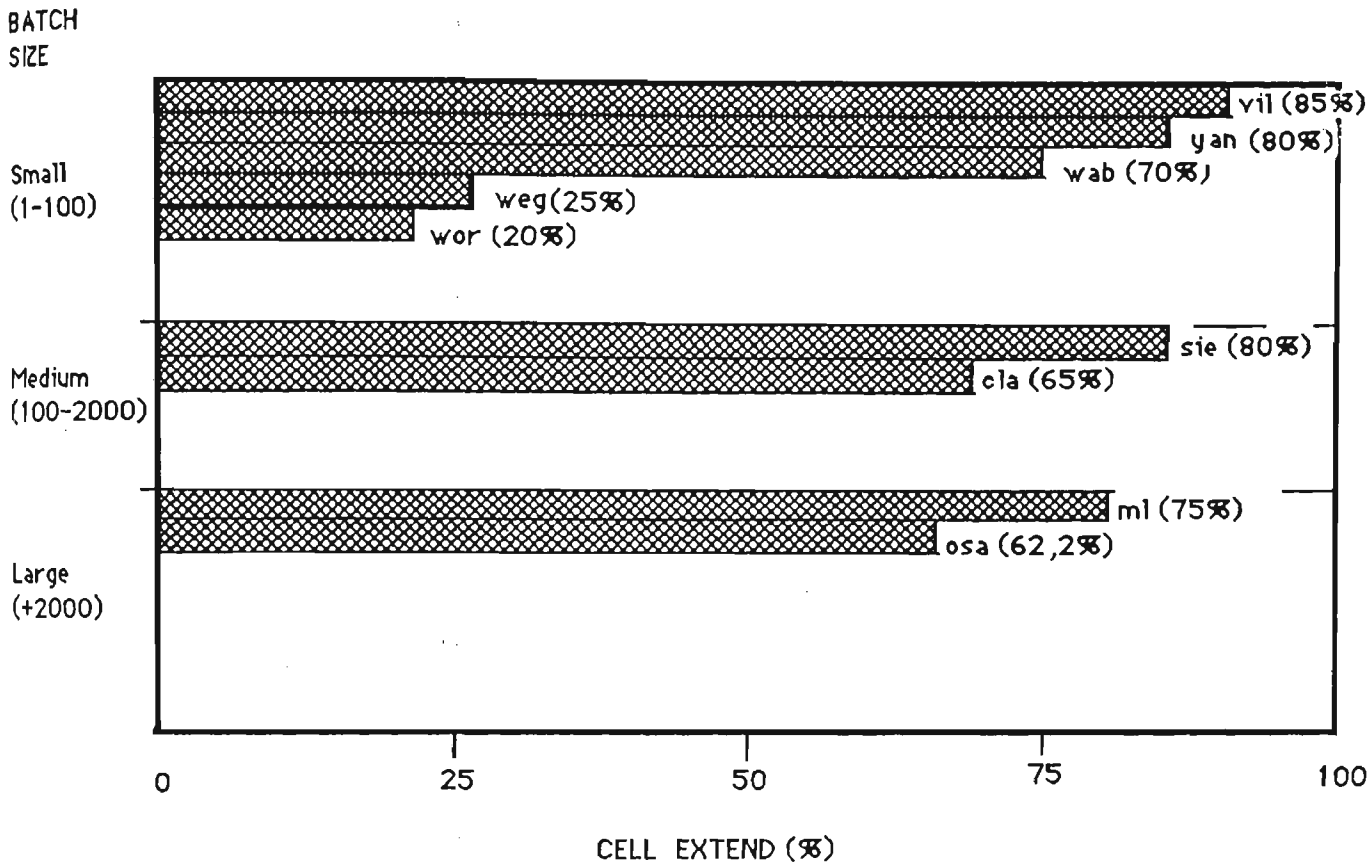


EXHIBIT 7.6: Horizontal cellularisation extent and batch size

feasibility needs²⁰⁸. The researched firms that achieved a higher degree of horizontal cellularisation, reorganised process technology independent of product profile (product customisation feasibility), batch size and, to a lesser extent, did so from the type of manufacturing process required.

Because the above indicators are insufficient in explaining the cellularisation process, complementary indicators were examined in order to explain it further. In the next chapter an analysis of the vertical dimension is made. Quantitative indicators are used to throw some light on the reasons and processes behind the quality of the cellularisation process. These qualitative indicators allows for the examination of the degree of human-centredness at shopfloor and firm-wide level.

²⁰⁸ The examination of manufacturing strategies of the researched firms in chapter 8 provides evidence of this point.

CHAPTER 8

THE VERTICAL DIMENSION

8.1 INTRODUCTION

This chapter examines the vertical dimension which refers to the work and organisational activities performed both at the shopfloor and the firm-wide level. The vertical dimension concept is used as a means to unravel the extent to which principles, implicitly or explicitly, were applied in the researched firms.

Work groups, job rotation, use of skilled labour and the delegation of autonomy to shopfloor workers, in order to perform the co-ordination, planning and controlling of manufacturing activities, are some of the functions which are widely recognised as crucial to obtaining productive efficiency in highly uncertain and highly complex manufacturing activities (cf Kidd, 1992). Nevertheless these concepts can be applied to a wide range of degrees. That is, they can be applied selectively in specific work units or firm-wide and the degree of application in each work unit can vary to a significant extent.

A large part of research performed to assess those structural changes, are of an aggregate nature²⁰⁹. That is, they map the extent to which those techniques are being diffused in particular industries or sectors, but do not give information about the quality of the changes introduced. The latter is crucial, because different production organisation strategies produce different technological, economic and social outcomes. Even applying the same principles under the umbrella of NPCs²¹⁰, for example, different orientations and results might occur as in the case of lean production system versus the HC model²¹¹.

²⁰⁹ Out of a handful of exceptions such as Weber and Ulich's (1993) and Berggren (1991) among others, many survey-based studies exist which describe use of those novel work and organisational techniques solely in aggregate form. For statistics about Japanese transplants in the US, see Kenney and Florida (1993). For figures of German metal-working industries, see Saurwein (1993) cited by Jurgens (1993).

²¹⁰ For further details see Chapter 1.

²¹¹ Despite the existence of a series of case-study based research, there is still an unfinished debate about both productivity gains and competitiveness under two key strands of NPC: the lean production and the HC model. Details of debates in Adler and Cole (op cit), Berggren (op cit).

The present examination regarding the quality of work structures is an attempt to fill that research gap. The methodology used tries to systematise the data in order to clearly differentiate work structure strategies and types. It shows the extent to which firms have applied individual technical and socio-organisational principles. Because of shortfalls of aggregate data (surveys), the present methodology, by characterising types and degree of work and organisational changes, is used as a tool to evaluate and build a typology of an holistic restructuring process, as well as different types of restructuring.

The methodology used to measure the extent HC principles were applied is based on multi-dimensional organisational model presented in chapter 4. The model has 4 components. First, the degree of decentralisation of the technical manufacturing system. Second, the degree of end-user control over development, management, control and operation of the manufacturing system. Third, the organisational structure possessing low vertical and horizontal differentiation and extensive use of integrative organisational mechanisms. Four, the direct productive work characterised by low levels of work method uniformity, work flow rigidly and synchronisation. All these features constitute the core of the HC concept presented and explained in chapter 4.

In order to assess the vertical dimension, a series of representative indicators have been developed in order to examine the quality of changes. Nevertheless, the decentralised technical manufacturing system criterion was not applied, as organisational factors are regarded as more important than technical ones in creating HC systems in Brazil. This is due to the general low level of technological intensity existing in Brazilian firms²¹². As commented above, what differentiates a HC form from a non-HC form is the quality and amount of both direct and indirect activities a direct production worker performs and is responsible for. These two sets of indicators reflect the degree of decentralisation achieved in the manufacturing system that, in turn, is a key component of the HC model. Because HC literature has already stressed the importance of treating them in depth and as a separate category (cf Brodner, 1989; Auer and Riegler, 1990) we have developed a more sophisticated set of categories to further the debate.

Three sets of indicators have been developed. The first two are representative of shopfloor operations and the last one represents overall firm organisational structure.

²¹² Ferraz et al.(1992) conducted a survey of high technology user firms, finding that: (i) in the design sphere over 60 % of firms were low intensity users (ie used new technology in less than 10 % of design activities);and (ii) in the production sphere 46 % of firms were low intensity users and 43 % of firms middle intensity users (ie used computer-based manufacturing equipment for between 11 and 50 % of potential operations). Further explanations in chapter 1.

(i) Direct manufacturing indicators, represent the extent to which the direct control of operations and timing is transferred from PPC department responsibility to direct workers. They are intended to capture the extent to which micro (ie detailed) planning, controlling and co-ordination of some manufacturing activities are carried out inside or outside a work unit. These are directly related to technical efficiency by facilitating co-ordination and execution of operations at shopfloor level. This group of indicators attempts to reflect HC criteria of end-user control over management and control of the system.

(ii) Indirect manufacturing indicators, represent the range of indirect manufacturing activities performed by direct workers. This seems to favour technical efficiency and directly promotes direct worker motivation and commitment to work through acquisition of relative control over their own immediate work environment. This group of indicators reflects HC criteria related to the quality of work organisation (allocation of functions).

(iii) Wider organisation structure indicators, as the name indicates, refer to firm wide organisational changes introduced in order to support shopfloor level human-centredness. These factors not only affect manufacturing activities but all of the firm's operations. They are related to the existing firm's (institutional) capabilities in organisational, labour skills and reward system terms. They are deployed not only to promote organisational efficiency (eg better co-ordination between different departments/sections), but also to support personnel subjective job motivation and resources to further improve their technical and social capabilities. This set of indicators mirrors the HC criteria related to the achievement of decentralised and integrated organisational structure.

Exhibit 8.1 illustrates the two sets of indicators under two contrasting approaches. Shadowed indicators represent direct manufacturing indicators and indicators inside the box represent indirect manufacturing indicators. Exhibit 8.1(a) represents a typical tayloristic production planning and controlling organisation in which, manufacturing operators only execute orders issued at departmental or supervisory levels. Conversely, Exhibit 8.1(b) illustrates those cases in which some micro manufacturing planning and controlling, as well as indirect manufacturing activities, have been reintegrated into the work unit level, eliminating supervisory levels and indirect specialists such as QC inspectors or machine setters.

These indicators assess the degree of human-centredness adopted in studied firms and attempts to explain the HC-type configurations in Brazilian firms. In the following sections, each group of indicators is described and examined separately. This chapter suggests that the isolated examination of each group of indicators, that in turn reflect a specific sphere (ie

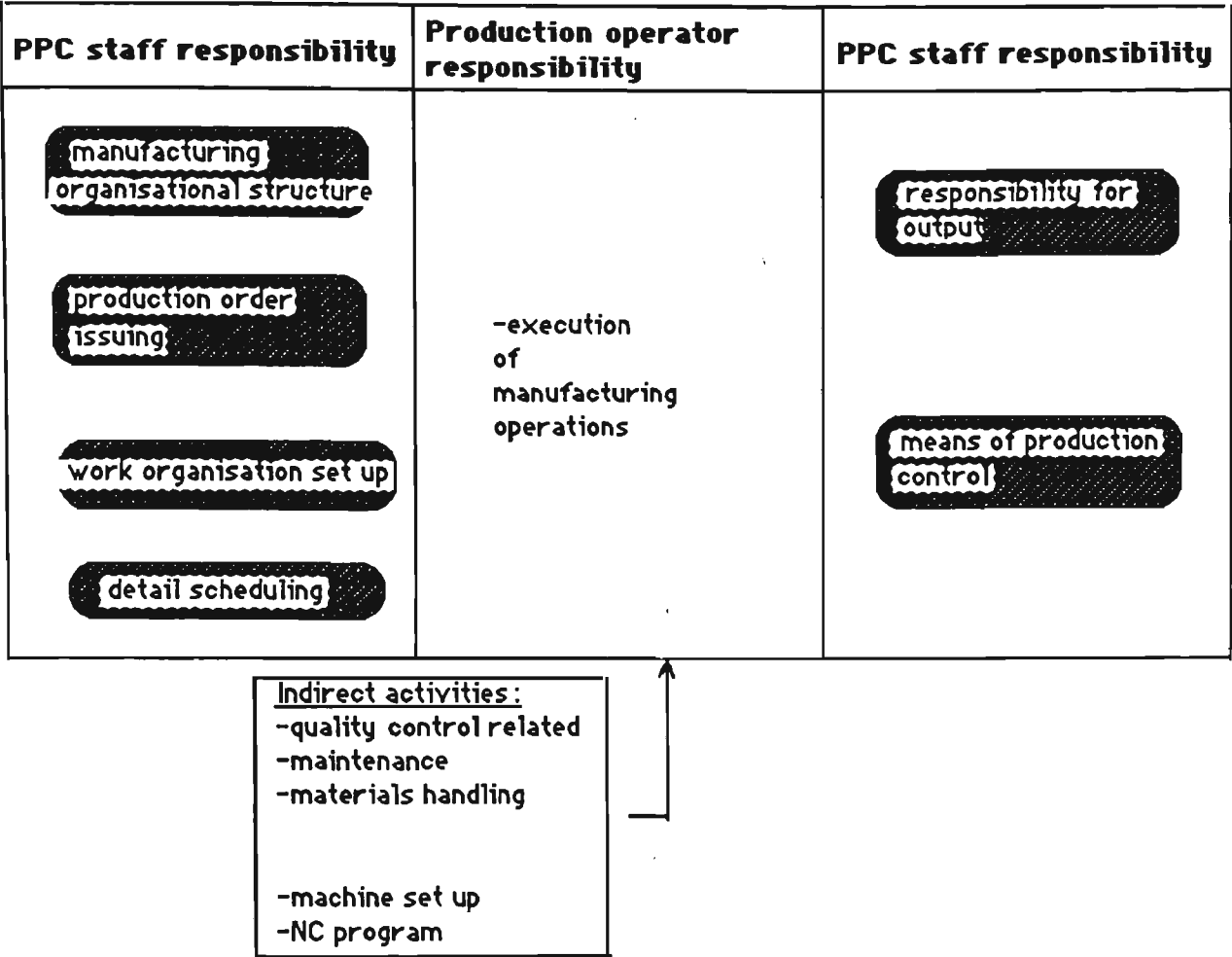


EXHIBIT 8.1a: Key manufacturing organisational dimensions:
A non human-centered approach

PPC staff responsibility	Production operator responsibility	PPC staff responsibility
<div>manufacturing organisational structure</div> <div>production order issuing</div>	<div>work organisation set up</div> <div>detail scheduling</div> <div>-execution manufacturing activities</div> <div>-indirect activities -quality control related -maintenance -materials handling -coordination inside work unit -machine set up -NC activities</div> <div>responsibility for output</div>	<div>means of production control</div>

EXHIBIT 8.1b: Key manufacturing organisational dimensions:
A human-centered approach

shopfloor and firm wide), does not provide enough evidence to sharply differentiate HC type firms from others. Finally, this chapter ends making some comments on the relationship between the general organisational design configuration applied and productivity levels.

8.2 DIRECT MANUFACTURING INDICATORS

In this section, a group of indicators is developed and used to examine how PPC department organisational structure was deployed and the extent to which some micro PPC planning and controlling activities were transferred to the shopfloor. First these indicators are described; second, using empirical data, the results are displayed in a 'radar' scheme; and a discussion of the findings is presented.

Before starting to describe the indicators, it should be stressed that the analysis in and around to which PPC functions is relevant to HC theory as it throws light on the key issue of the extent to which firms really transfer some micro control and planning PPC activities to the shopfloor. Although these indicators contribute in distinguishing the degree of human-centredness in manufacturing environments, they are not unique. Indirect manufacturing indicators complements them.

Manufacturing organisational structure, production order issuing system, means of production control, responsibility for output, work organisation set up, detail scheduling and production follow-up are factors considered in this group. Indicators are used to capture information regarding how a production department is organised generally, and how manufacturing operations are co-ordinated, divided and executed at work station level, in particular. That is, they show how planning, co-ordinating and controlling activities are distributed between PPC department and shopfloor level. Each factor might possess a higher or lower degree of human-centredness depending on the criteria outlined below²¹³.

(i) *Manufacturing organisational structure* indicators describe how the production department is deployed and how it is organisationally related to other departments. The reason for look outside production department boundaries is that, to be efficient, shopfloor work structures need a corresponding 'modern' wider organisational structure. That is,

²¹³

Following the general HC criteria detailed in Part I, the indicators would possess a higher degree of human-centredness in situations where the same personnel (group/individuals) execute manufacturing operations entailing the performance of: (i) detailed planning and co-ordination activities; (ii) indirect planning activities; and (iii) output control. In addition, departmental level organisational arrangements must support HC activities at shopfloor level.

organisational structure of manufacturing operations that support co-ordination tasks among different hierarchical levels inside the production department. This dimension provides clues to how tasks, inside the PPC department, are organisationally structured.

The manufacturing organisational structure index is a compounded index possessing two components. First, the type of organisational mechanisms applied to co-ordinate activities between the planning/control department and shopfloor level. Second, time and effort spent by areas responsible for co-ordinating productive activities at intra cell level. These indicators are complementary because the former indicators provide an idea of the organisational structure type used, and the latter reflects the effectiveness of that organisational structure.

I. Co-ordination type	Index
-bureaucratic	1
-formal hierarchy	2
-direct management control	3
-matrix or project structure	5
-work group	6
II. Time and effort	
-maximum time/effort required	1
-considerable time/effort	2
-moderate time/effort	3
-limited time/effort required	5
-minimum time/effort required	6
Total Index = (I+ II)/2	

Exhibit: 8.2 Manufacturing Organisational Structure Index

The higher the index value, the higher the degree of human-centredness possessed by this indicator. Therefore, matrix, project structures and work group items are defined following Rohloff's (1993: 363) idea of decentralised production planning: "... based on a distribution of production and operation management tasks to interacting autonomous organisational units. The key feature is the integration of planning, realisation and control tasks". Concerning time and effort needed to co-ordinate PPC related activities, the less time and effort required by the PPC area for planing, controlling and co-ordinating productive activities inside and between cell (or work units), the more these activities would support human-centredness. For example, the more self-managed the work unit, the higher the degree of human centredness the work unit possesses.

(ii) *Production order issuing* was carried out in studied firms in two ways²¹⁴: (i) production ordering using traditional 'production orders'; or (ii) ordering productive activities through the Kanban system. The former is composed of two complementary indicators: production order frequency and degree of detail of production orders²¹⁵. Production order frequency denotes the frequency in which production orders arrive at the manufacturing cell. The lower the frequency, the higher the degree of human centredness. The opposite also applies. Production order detail refers to the degree of detail which a particular production order possesses. That is, to what extent a production order explicitly and formally indicates how to develop manufacturing operations. In this case, the higher the degree of detail in the production order, the lower the level of human-centredness the production control system possesses. Exhibit 8.3 shows the criteria for the index allocation for this item.

Type of Production Order Issuing	Index
I. Traditional PO system	
PO Frequency:	
High (1xday)	1
Medium	3
Low (1xweek)	6
PO Detail:	
High	1
Low	6
II. Kanban PO system	3
Index I= (PO frequency + PO detail)/2	
Final Index: = I or II	

Exhibit 8.3 Production Order System Index

Kanban, is an alternative method of ordering and controlling productive activities. By using it, two main elements of the productive system can be controlled. Firstly being, the materials in process inside the cell, since the Kanban system performs the role of an implementer of the production plan (at macro level) and also releases production orders. Secondly, it controls

²¹⁴ Other forms for performing production order issuing and scheduling such as the drum-buffer-rope technique based on the theory of constrains (cf Schragenheim and Ronen, 1991; Aggarwal, 1985) were excluded because none studied firm applied it.

²¹⁵ It needs to be noted that frequency and detail of production orders can also be considered in the case of a Kanban system. However, in the case of Kanban both are more or less standardised. That is, frequency is relatively high and detail of production orders is low as products are relatively standardised. Thus, we have considered both PO frequency and PO detail only in the case of a traditional production order system as, theoretically, they are used in cases of high variability of output (volume and mix).

production flows between different cell as Kanban performs the role of production order (micro) planning and releasing. Those functions occur at the same time within and/or between cell. In this way the Kanban system, by definition, implies a higher interdependence among tasks performed at different work stations (cf Karmarkar, 1989; Arogyaswamy and Simmons, 1991). However, in order to test if the Kanban system leads more towards a supportive or a hindering role of human-centredness, it is necessary to look at buffers that might exist inside and between different cell or work units. If buffers exist inside loose interdependence is possible which, in turn, means a favourable outlook towards human-centredness. Conversely, if buffers do not exist, tight interdependence might exist, hindering human-centredness. Therefore, the Kanban production control system might lead to different situations either supporting or constraining human-centredness at the shopfloor level, depending on the actual buffer configuration²¹⁶. It is also possible to suggest that intra and inter cell buffers, as well as Kanban techniques, might perform the key role of the decoupling processes. However, it will be the buffer level and not the pull Kanban which will determine the existing degree of interdependency. Kanban by itself, might increase or decrease the interdependency level depending on final demand. Thus, a 'neutral' index number is assigned to the Kanban production control system item. Three is the assigned index number for firms using Kanban.

(iii) *Means of production control* indicates the means used by management to control work performance. That is, to control the achievement of output mix and due dates. The data collected indicated that there were four main types of production control: (i) direct personal control performed by a supervisor, or bureaucratic control (such as filling forms that are periodically checked by a supervisor); (ii) output control using organisational methods like the Kanban system; (iii) detailed accountability devices used to measure performance in terms of scrap, defects, items returned, due date achievement and planned mix of output; and (iv) the linkage of performance measures to a reward system.

The more output measures are used for production control, the higher the degree of human-centredness is assigned to this indicator. A higher degree of human-centredness is attributed when the output control organisational mechanisms are linked to a reward system. That is, part of the operator's wage is a direct function of the operator's and or the group performance. Exhibit 8.4 details the criteria used for the index.

²¹⁶ This argument is in line with Black's (1991) 'decouplers' concept. "The decoupler breaks the dependency of the process on each other in a cellular environment. Decouplers hold one part and have specific input and output points...[Kanban decouplers] provide for production control within the cell, controlling the timing of the operations and creating flexibility, in the staffing (manning) of the cell, which provided flexibility in the cell production rates" (p.190).

Production control device type	Index
-personal (direct)	1
-Kanban	2-3
-bureaucratic	4
output linked to reward system	6

Exhibit 8.4 : Means of Production Control Index

An index number between 2 and 3 is assigned in cases where the Kanban system was fully implemented. The reason for the index is because of the 'detailed' nature of the Kanban accountability system which is subject to the direct control of supervisors and peers. Again, the buffer configuration in this case, is a key factor to further determine the degree of human-centredness.

(iv) *Responsibility for output* points to the hierarchy level which is responsible for the delivery of a planned mix of output on proposed due dates. The more the responsibility for the output lies near the point of operation, the higher the degree of human-centredness. Exhibit 8.5 details criteria used for index allocation.

Responsibility for output	Index
-Direct workers	1
-Team work and supervisor	3
-Team work	6

Exhibit 8.5: Responsibility for Output Index

This indicator is, to a significant extent, associated with the manufacturing organisational structure indicator, but final responsibility for output (in terms of obtaining correct mix and due dates), is not necessarily determined by that indicator.

(v) *Cell Work organisation set up* refers to how work organisation is set up at cell (or work unit) level, who takes the final decision regarding cell internal functioning and how work is distributed among different work unit members, including execution, supervision and co-ordination activities. That is, excluding detail scheduling, it involves all micro planning and co-ordination activities needed at the cell level. Those decisions might occur formally or informally. Exhibit 8.6 details criteria followed to allocate index numbers in this indicator.

Cell work organisation set up	Index
-supervisor or PPC staff	1
-leader with group work	3
-group work	6

Exhibit 8.6: Cell Work Organisation Index

It is necessary to note that after formal work organisation is set up and detailed scheduling, cell members may still possess a certain degree of freedom to re-organise their own activities. Real work organisation does not necessarily match a formal work organisation set-up. During the empirical data collection period, it was observed in the researched firms that, in several cases, even after a detailed prescription on how to perform manufacturing tasks, operators possess enough experience to perform the same task in different ways. That is, operators are able to change pre-stabilised procedures informally. The latter represents the so called workers' control over the labour process. Different degrees of 'operator space' exist, depending on the technical devices set up to chase productive activities, the firm's ability to enforce production orders, manufacturing procedures standards as well as worker experience/tacit knowledge of the production process. That is, the negotiation processes occur formally/informally between key social actors during the implementation process (see chapter 4). To simplify this, the informal work 're-organisation' carried out by operators is included in the cell work organisation set up indicator.

(vi) *Detail scheduling* refers to the hierarchical level in which intra-cell detailed scheduling is made. Detailed scheduling involves the issue of detailed production orders and the management of a timetable regarding starting and ending times of operations. The more productive personnel perform detailed scheduling of their own activities, the higher the degree of human-centredness. Exhibit 8.7 shows the criteria used in the present case.

It is important to note that several methods exist to schedule shopfloor operations which can be easily performed by a shopfloor operator. The Gantt graphic method, for example, can be used in a decentralised way by shopfloor operators in different cells. Co-ordination and communication, at shopfloor level, among highly interdependent cells, is also facilitated by the proximity of cells. HC computer-based scheduling software still does not exist (Martins, Schallock and Carbon, 1993), but is being developed to be used in technologically intensive manufacturing environments. In the Brazilian researched firms, this is not necessary due to the existing low levels of AMT intensity.

Detail scheduling activities performed at the point of operation by a direct worker, is important for HC principles as this contributes to favouring semi-autonomy to handle problem-solving, co-ordination and/or productive work along worker's own capability and firm needs.

Detail scheduling performed by	Index
Leader and work group	1
Supervisor or PPC staff	3
Work group	6

Exhibit 8.7: Detail Scheduling Index

(vii) *Production follow-up* refers to the hierarchical level in which the control of operations progress occurs. This can be done by cell members or by external persons outside the cell, such as a foremen. As with the previous indicators, the more direct manufacturing personnel perform production follow-up activities, the higher the degree of human-centredness this indicator possesses. Exhibit 8.8 details criteria of index allocation.

Production follow up performed by	Index
Individual external to group work	1
Group work	6

Exhibit 8.8: Production Follow up Index

Before examining collected data, two clarifications regarding the described indicators are needed. Firstly, indicators developed can be grouped into two. On the one hand, indicators (i) to (iii) reflect manufacturing activities related to macro planning of inputs (ie what products are to be produced, in what volume and when), and control of those outputs, in terms of what types of organisational means are used to control operational results. Functions represented by those indicators are traditionally set up at departmental level. However, the way inputs and outputs are planned and controlled shape to a significant extent, intra work unit production and work organisation characteristics. This is why it is important to make those characteristics explicit.

On the other hand, indicators (iv) to (vii) reflect how micro planing and controlling activities are carried out. Under the HC model, these activities are performed by the executing work

group. These four dimensions are important because they represent the reintegration of formerly fractionated functions into routine activities for the working group; those planning and controlling activities, performed at cell level, not only facilitate macro planning and controlling activities of the PPC department, but also favour organisational efficiency. Brodner (1991) and Rohloff (1993) for example, suggest that because detailed planning and control activities are better performed at the point of operation by operative personnel, significant organisational efficiency might be achieved. Additionally, shopfloor personnel morale increases due to the new (more important) type of work performed. Therefore, the most advanced manufacturing systems case will be the one in which dimensions (iv) to (vii) were performed by cell members.

Secondly, the above indicators, while representing a key measure of the degree of human-centredness are not the only ones. Other dimensions are important to any productive system, but do not change (or change to a small extent) under application of HC criteria. Macro scheduling for example, while crucial to production operations planning, is not important to the human-centred model due to the fact that its role remains the same under either HC or non-HC strategies. That is, macro scheduling activities will continue to be performed at production planning department level under traditional or HC arrangements.

Next, an examination is made in the following section differentiating firm by firm strategies of shopfloor restructuring based on empirical data summarised in Exhibit 8.9.

Item	Yan	Wor	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb (c)
(i)	3	2.5	3.5	2.5	4	6	2.5	4.5	2.5	3.5; (5) [1]
(ii)	3 (a)	1 (6) (b)	n.a.	3 (a)	3	3 (a)	2	3 (a)	3 (a)	3; (6) [2.5]
(iii)	3 (a)	1.5 (4) (b)	3	2.5 (a)	6	6	2	3 (a)	3 (a)	1.5; (1.5) [1.5]
(iv)	3	1 (1) (b)	2	3	3	6	1	6	6	3; (1) [1]
(v)	2	1 (6) (b)	n.a.	2	4	4	1	6	4	2; (3.5) [3.5]
(vi)	1	1 (6) (b)	n.a.	1	2	4	1	2	1	2; (1) [1]
(vii)	3	1 (6) (b)	n.a.	3	6	6	1	6	3	1; (5) [1]

- (i) Manufacturing organisational structure
(ii) Production order issuing system
(iii) Mean of production control
(iv) Responsibility for output
(v) Cell work organisation set up
(vi) Detail scheduling
(vii) Production follow up
- (a) Kanban system fully installed
(b) Refers solely to cell areas
(c) At Emb firm, three plants exist. First index number refers to assembly operations; second one to machining operations (tool & die plant) and third one to machining operations (production in series)
n.a. means data not available

Exhibit 8.9: Direct Manufacturing Indicators

Direct Manufacturing Indicators: An Examination

Exhibit 8.10 details the extent to which individual firms have applied HC principles in this set of indicators. Based on the extent of the implementation of HC principles, researched firms have been classified into three groups: tayloristic or non human-centred, firms combining taylorist and HC principles, and ‘HC oriented’ firms.

Firms possessing an indicator index lower than 3 were classified, as applying production organisation arrangements in Tayloristic patterns in terms of PPC department/section work organisation, work control and follow up activities (see Exhibit 8.10a).

Firms possessing an indicator index around 3 are those identified as possessing a low level of human-centredness. That is, some production planning and controlling activities have been partially transferred to shopfloor workers, but control of micro planing and controlling activities, remains in the hands of the PPC department through the extensive use of supervisors (see Exhibit 6.10b). A tentative explanation might be that the firm is a 'transitional' stage of implementation. However, indicators in this position can evolve either towards HC or neo-tayloristic forms. It can not be assumed that they will necessarily follow a HC path.

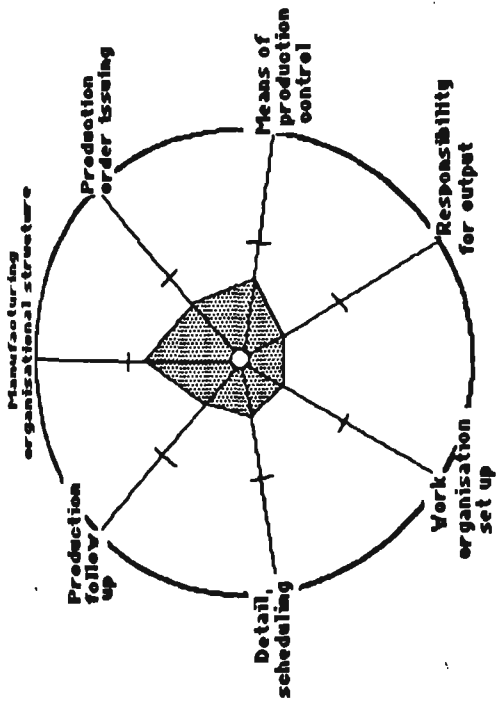
Firms possessing an index number above 3 in the majority of cases were classified as having from medium to high human-centredness. This means that key micro level PPC activities were transferred to direct workers.

It can be noted from Exhibit 8.10c that work structures were not homogeneously restructured when compared to work structures displayed in Exhibits 8.10a and 8.10b. That is, organisation restructuring occurred to a significant extent along HC principles in the majority of this group of indicators (Exhibit 8.10c). However, in all cases, at least one indicator scored low. It should be noted that in all the firms studied, the restructuring process was a very recent event and was still under continuous evolution at the time of data collection.

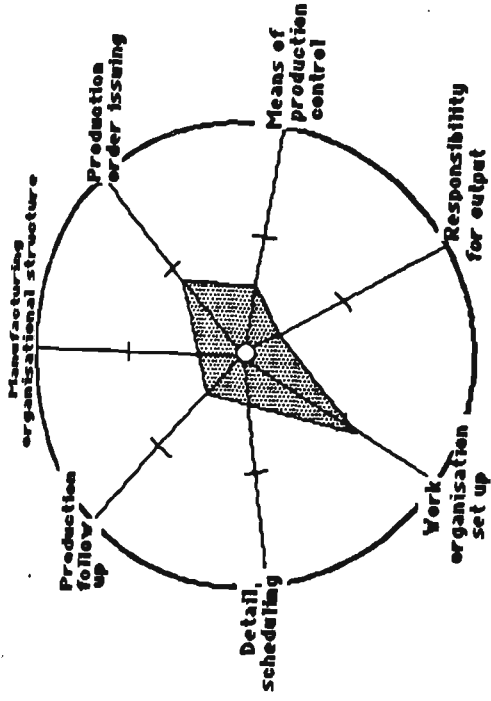
Surprisingly, indicators scoring a low level of human-centredness (index number lower than 3), were different among the six HC type plants. In the cases of 'osa', 'sie', 'vil' and 'wab' for example, they implemented HC principles in all indicators but in 'production order issuing'. Detail scheduling at 'emb 1', Vil, 'wab' and 'sie' had a low score. This means that while this is a crucial indicator in terms of maintaining managerial control over micro manufacturing activities, in some firms, this might not be the case in other firms.

Evidence also points out that HC oriented firms displayed a high degree of heterogeneity regarding the examined manufacturing organisational indicators, not only between them but also inside each plant. This heterogeneity can be tentatively explained by different organisational design implementation strategies and different contingency factors affecting them. Implementation is also directly connected to power relations at middle and top managerial levels²¹⁷.

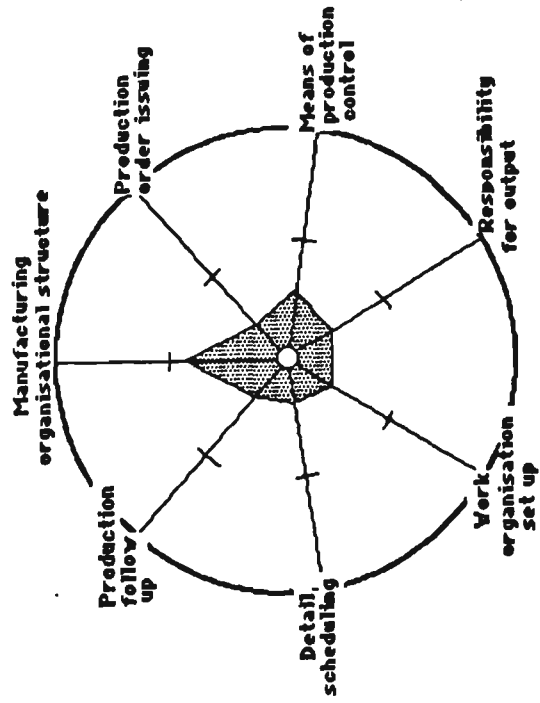
²¹⁷ Low HC applied items for example, were implemented first where they would not challenge the entrenched power relationships.



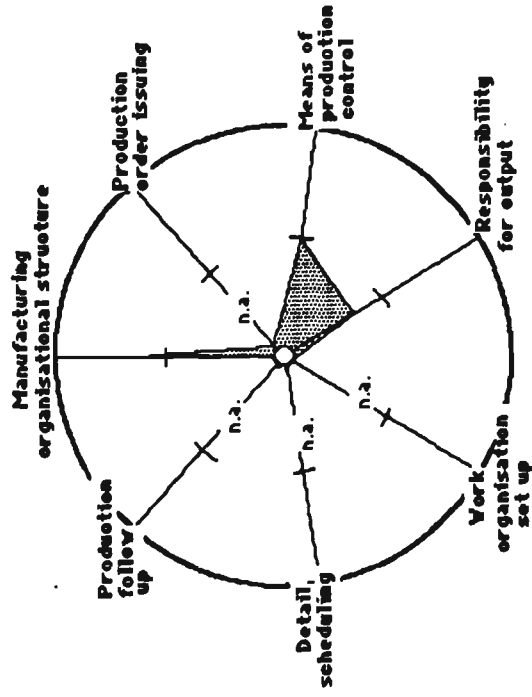
WEG



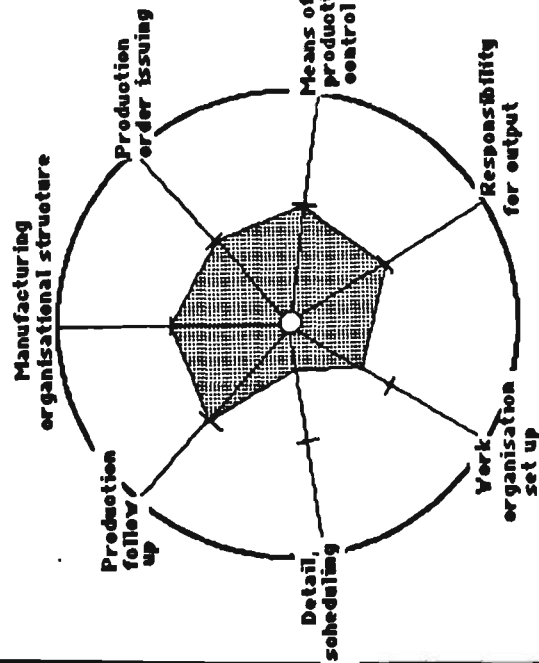
EMB 3



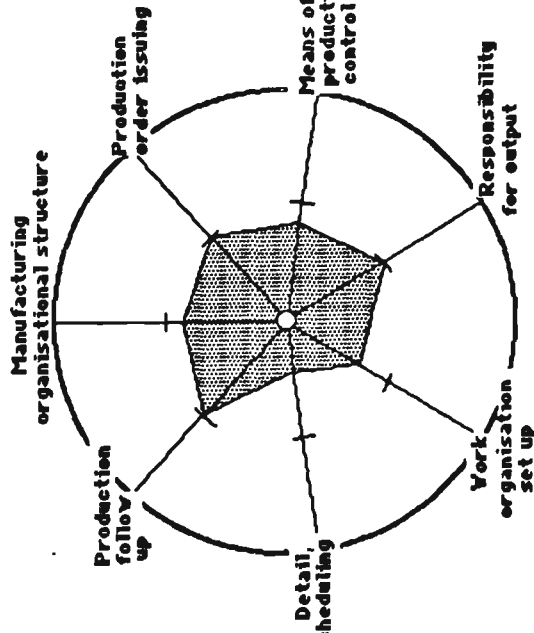
WOR 2



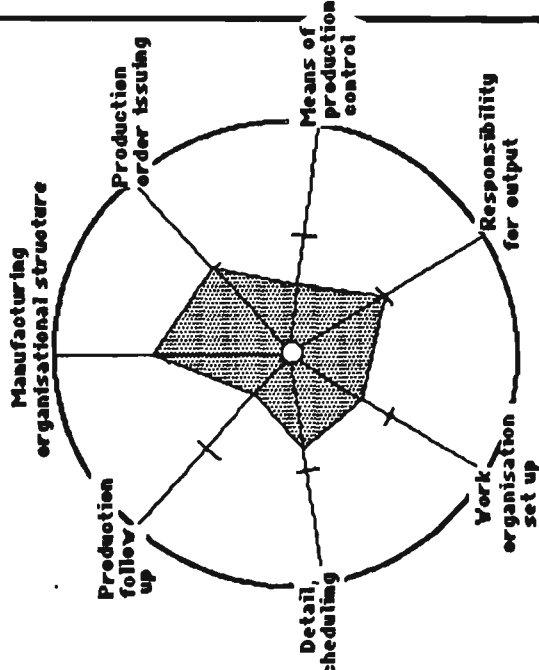
ML



VAN

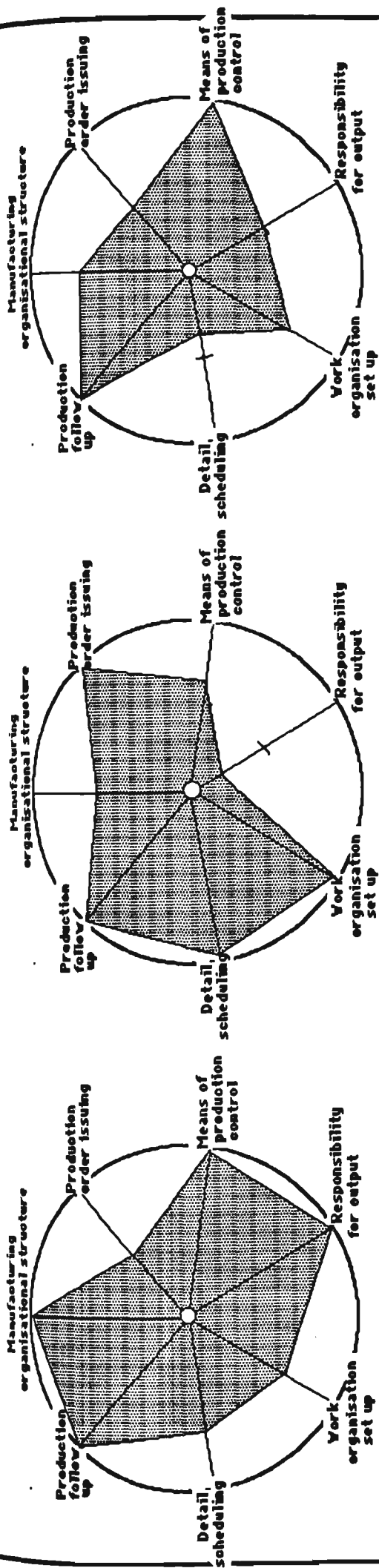


CLA

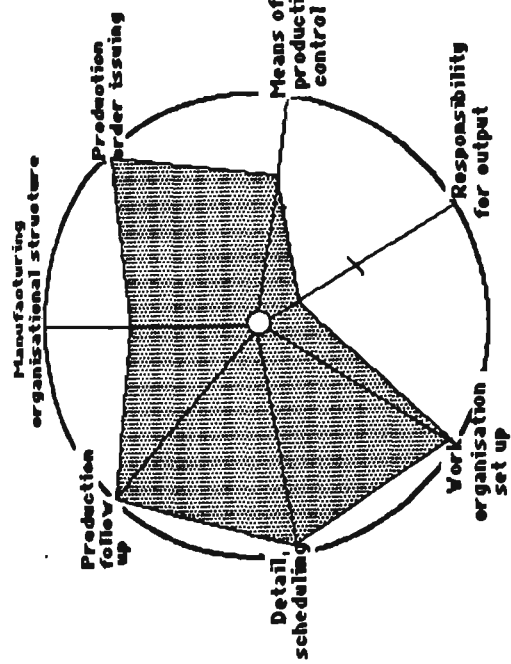


EMB 2

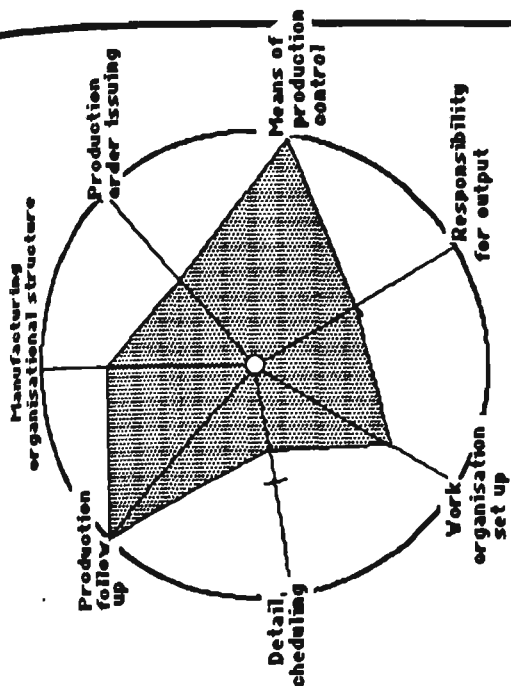
EXHIBIT 8.10b: Direct Manufacturing Indicators:
Low level of human-centredness



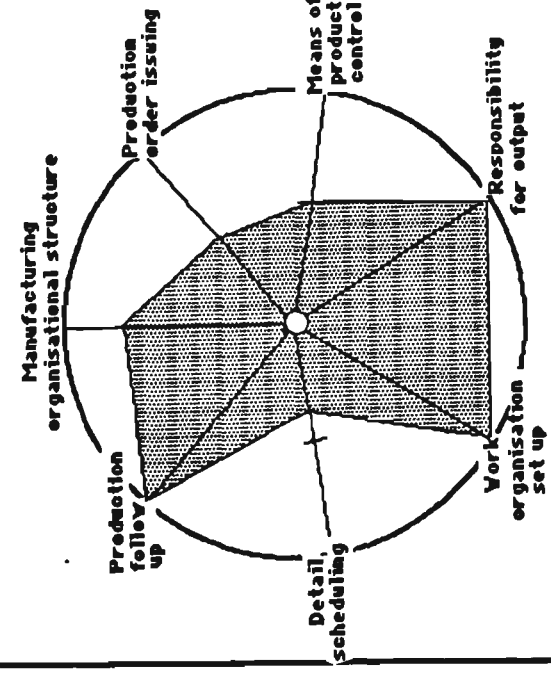
OSA



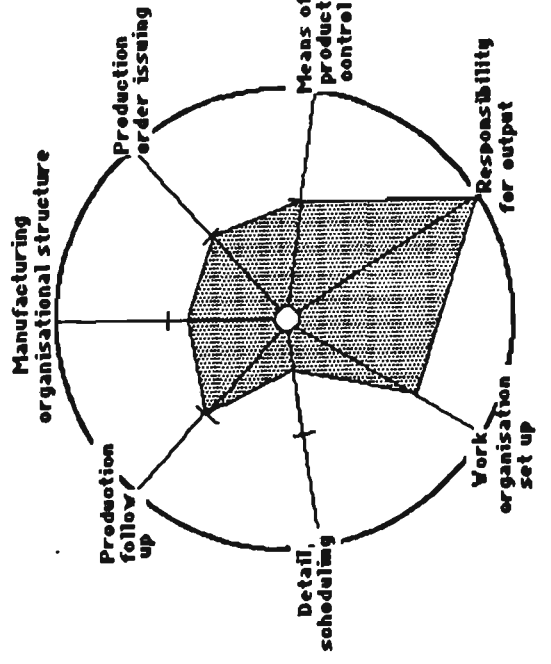
WOR 1



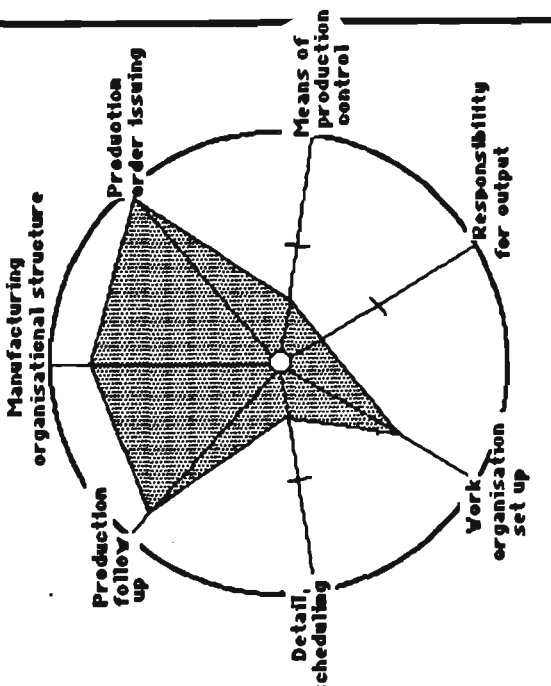
SIE



WAB



VIL



EMB 1

EXHIBIT 8.10c: Direct Manufacturing Indicators:
Medium/high levels of human-centredness

In general terms, it was possible to observe an homogeneous pattern of restructuring in non-HC firms (Exhibits 'a' and 'b') and an heterogeneous re-structuring in HC-oriented firms (Exhibit c). Heterogeneous configurations of HC 'oriented' firms suggests that: (i) there are different ways to implement HC principles; (ii) each firm adapts the HC model to its own ends; (iii) human factors, (ie politics, resistance to change and misunderstanding) seem to be mainly responsible for the final organisational configuration. What is important, nevertheless, is the extent to which firms in medium to high human-centredness level implemented those changes. This highlights that new organisational forms do exist and are feasible in the Brazilian environment. Moreover, it points out that management is clearly committed and accepts transferring some (detailed) decision-making activities to manual workers through re-uniting execution tasks with micro production planning and controlling activities. In all cases in which a high to medium human-centredness degree existed at the direct manufacturing Indicators group, management explained that manufacturing organisational restructuring was carried out aiming for further whole firm competitiveness improvement and not solely to achieve selective results such as better worker productivity, quality improvements or an increase in the flexibility of operations.

During the empirical data collection, it was observed that some firms possessed low levels of Human-centredness as a result either of organisational design or as function of middle management resistance.

Thus, evidence presented up to this point suggests that a high variability of HC manufacturing systems exists depending on the specific contextual conditions of each firm. These contextual conditions seem to be related more to current organisational and social issues than to product features (see Chapter 7).

8.3 INDIRECT MANUFACTURING INDICATORS

This group of indicators examines questions related to the extent to which direct workers control not only their direct operative activities but also their 'indirect' activities. To perform this examination, a series of indicators were developed. They are described below. Our working hypotheses in this section is that, as the implementation of the indirect manufacturing indicators group seems not to challenge managerial power, it is likely that a significant part of our studied firms deployed indirect work along HC lines.

The extent of rotation of shopfloor workers, quality control, statistical process control (SPC), routine maintenance, NC program improvement and machine tool set up activities directly performed by productive workers are the six items considered at the indirect manufacturing indicators group. Excluding the extent of rotation, this group of indicators complements direct manufacturing indicators group. Even though those functions are quite independent of each other, the more they are performed by the work-group, the more likely the manufacturing system will be HC-oriented. That is, manufacturing operators either perform all the above tasks indicated by the six activities or reorganise themselves horizontally and divide amongst themselves the most convenient way for the work group considering timing, volume and mix of output boundaries set up by management. Under tayloristic principles, individual components of indirect manufacturing indicators are performed separately by specialist personnel who do not belong to the executing working crew. Next, a brief definition of each indicator is given and the criteria used to allocate an index number is detailed.

(i) *Extent of rotation* refers to the extent to which cell operators rotate inside the cell or work unit. This indicator represents the extent to which they really operate different machines and perform different tasks inside the cell. At the micro level, the rotation degree inside the cells is a function of: (i) the existence of a organisational structure designed in such a way that allows the cell members to rotate; (ii) availability of skilled and experienced personnel who are able to work on different machines and work stations; and (iii) the willingness of operating personnel to perform different tasks.

The rationale to assign values is as follows: if operators can (and actually do) perform their tasks in all work stations (including all machine operations) inside the cell, a 6 value is assigned; value 3 is assigned if only 50 % of cell operators rotate among all machines/work stations; If no rotation occurs, a value 1 is assigned. Intermediary situations also occur and are qualified accordingly.

The key benefits of rotation (Susaki, 1987) are related to: (i) Providing opportunity for

workers to change their work pattern at pre-determined intervals; (ii) helping to prevent health/physical strain; (iii) facilitating sharing of skills; and (iv) encouraging teamwork so that the operators become aware of the total production process which in turn facilitates problem-solving activities). Therefore, high extent of rotation directly supports human-centredness.

(ii) *Quality control* refers to who performs quality control activities are performed inside the work unit. Three types were found, namely, the working crew, a person external to the cell (eg cell leader or quality control specialist) and both an external person and the working group. This item is associated, to some extent, with 'work organisation set up'. However, in the present case, quality control denotes who is doing quality control activities at shopfloor level (group or individuals internal or external to the working group); and where the responsibility of quality control activities lies. In this sense, quality control refers to an important manpower control aspect which does not depend on any arrangement adopted at 'work organisation set-up' level.

In the present case, if a working group is responsible for performing quality control activities, the index number assigned is 6. If the group and an external person perform those activities, the index number assigned is 3, and finally if an external person performs quality control activities, the assigned index number is 1. It should be noted that, even if quality control activities are performed inside cells, it can be done either under tayloristic (ie high horizontal division of labour) or under work group schemes.

(iii) *Statistical process control (SPC)* refers to the extent SPC activities are implemented at shopfloor level and are performed by work unit members. If SPC is not implemented, the associated index number is 1. If SPC is 100 % implemented, the index number is 6. Intermediary cases are qualified according to these parameters. Shopfloor workers performing SPC activities contribute to the effectiveness of the work group as it facilitates communication among them (Brennan, 1990). That is, SPC activities carried out by operators help to focus workers' attention upon locating problems and collectively solving them.

(iv) *Routine maintenance* refers to the extent to which routine maintenance activities are implemented shopfloor wide and are performed by work unit members. Routine maintenance activities might involve, amongst others, oil change, cooler change, cleaning, greasing, replacement of standard parts, belt adjustment, check of standard key points as well as its systematic control (using charts, forms) over a period of time. Machine repairs are not included in routine maintenance. Index 6 is assigned when routine maintenance activities have been implemented shopfloor wide and are performed regularly by team group members as part of their routine activities. 1 is assigned if the latter does not occur.

(v) *NC program* refers to the extent to which NC program related activities are performed at the point of operation by work unit members. In cases where cell members are allowed to change the actual NC program, the index number is 6. When work unit members are allowed to optimise (NC) input data, number 3 is assigned. Finally, in cases where work unit members are not allowed to intervene either in optimising or in changing the NC program, index number 1 is assigned.

Shopfloor worker's involvement in NC program improvement/re-programming brings efficient results as the cost of programming activities are lower when performed by shopfloor operators (Kelley and Lan, 1990). Because machine operators use Numerical Control Machine Tools (NCMT) and usually know the machining processes well (a crucial pre-requisite to improve the NC program) and provided they have been trained in computer programming activities, they are, usually, in a better position to perform these activities.

(vi) *Machine tool set up* refers to the extent that work unit members perform set-up activities with machine(s) (or work stations in case of assembly operations) on which they work. If set-up activities are performed by group member(s), index number 6 is assigned. If machine set up is performed by a person external to the work unit (eg a specialist who is not a work unit member), index number 1 is assigned. If cell members perform only simple activities or pre-setting ones, the index number 3 is assigned.

Based on empirical data summarised in Exhibit 8.11, next an examination is made differentiating between the firms strategies for shopfloor restructuring using the same three fold classification as in the previous section.

Item	Yan	Wor (b)	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb (a)
(i)	1	1 (1)	3	3	6	3	1	6	2	1 (1) [1]
(ii)	3	1 (1)	1	6	6	6	1	3	5	3 (6) [2]
(iii)	4.2	6 (6)	2	6	3	4.8	2	6	2	na (na)
(iv)	2	1 (1)	5	2	n.a.	(*)	1	3.6	1	[1,5] 1 (1) [1]
(v)	4	4 (n.a.)	3	4	1	(*)	2	4	2	na (6)
(vi)	1	n.a.	n.a.	2.2	1	(*)	3	1.6	1.5	[2.5] na (6) [1]

n.a. : data not available;
(*) not applicable as firm does not posses NCMTs
(a) the first figure refers to assembly plant; the second figure to tool and die machining plant; and the third number refers to machining plant producing by series
(b) Figure () refers to cell shop activities

(i) Extent of shopfloor worker job rotation
(ii) Extent of quality control activities performed by shopfloor workers
(iii) Extent of SPC activities performed by shopfloor workers
(iv) Extent of routine maintenance activities performed by shopfloor workers
(v) Extent of NC program improvement activities performed by shopfloor workers
(vi) Extent of machine set up activities performed by shopfloor workers

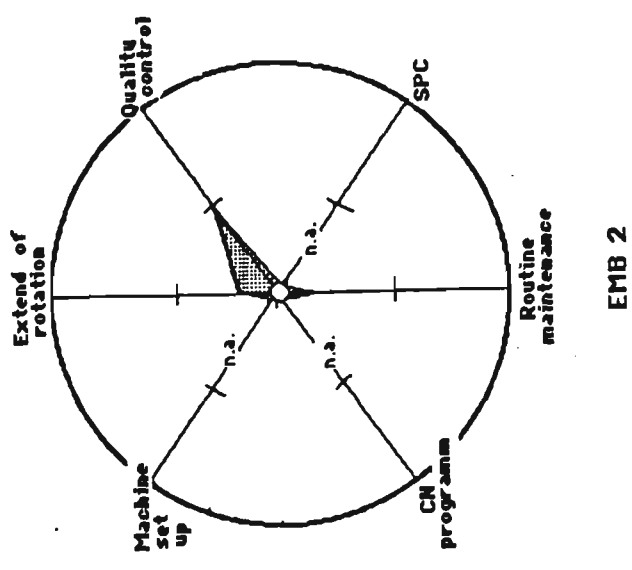
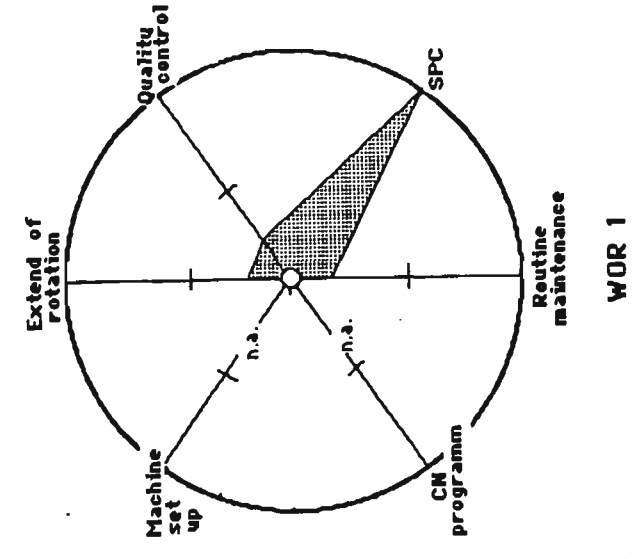
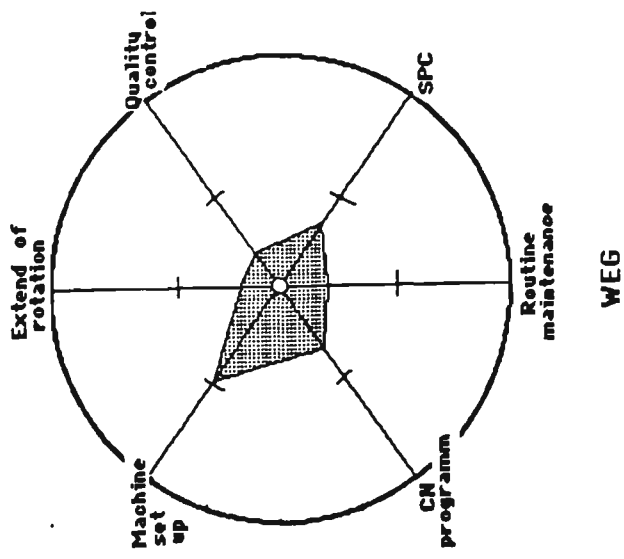
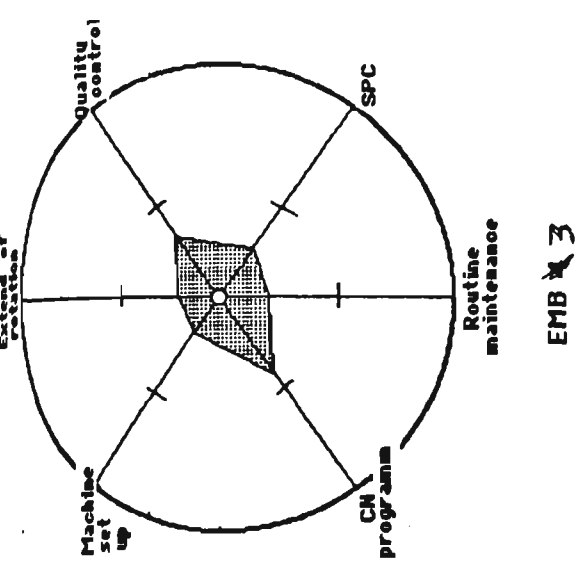
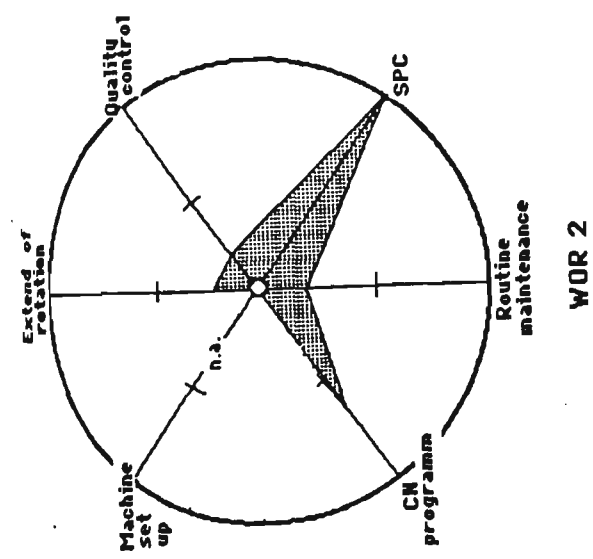
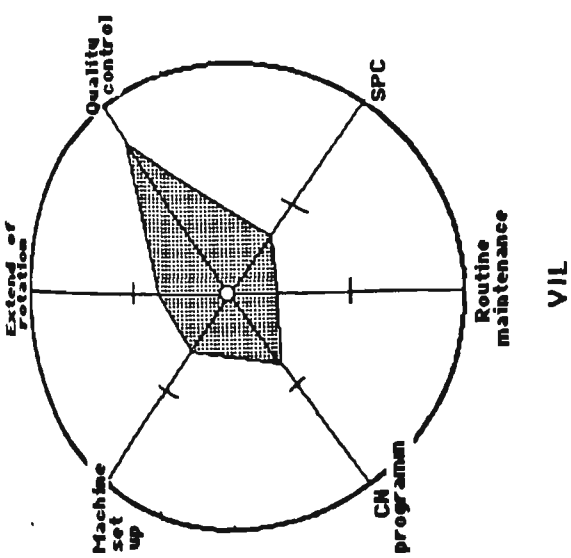
Exhibit 8.11: Indirect Manufacturing Indicators

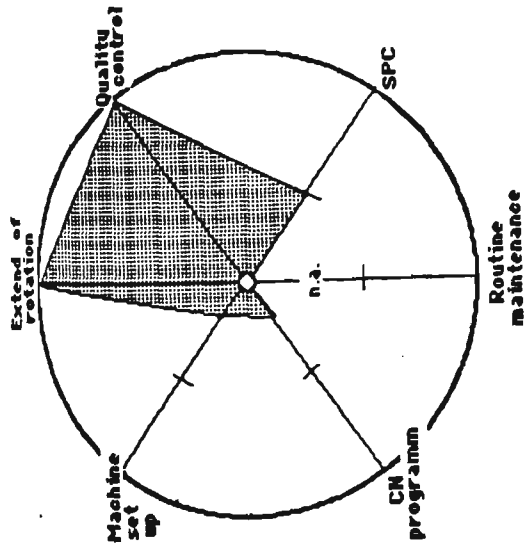
Indirect Manufacturing Indicators: A Qualitative Examination

Exhibit 8.12a details plants possessing tayloristic work structures in the indirect manufacturing indicators group. As can be noticed in the exhibit, they represent a significant number (6 out of 13 plants). That is, high division of labour exists in machine set-up, routine maintenance, quality control and NC programming activities.

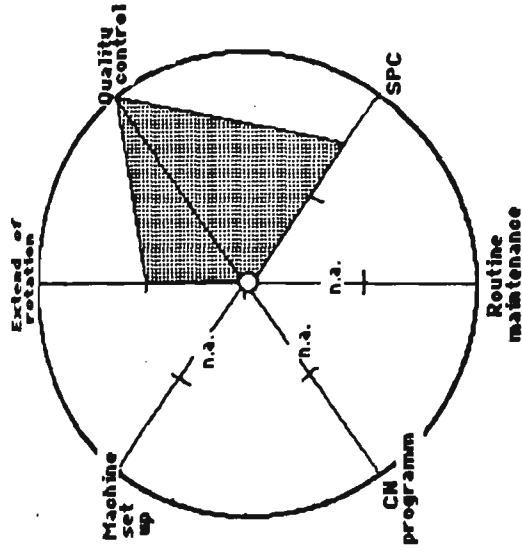
Exhibit 8.12b shows plants possessing a low level of HC work structures. That is, they possess an index number around 3. Two comments can be made about this type. First, all firms adopted from medium to high levels of human-centredness in two items while tayloristic principles prevailed in all remaining. At 'sie,' for example, both the extent of rotation and quality control indicators achieved a high degree of human centredness. That is, operative workers carried out quality control activities on their own work and they rotated tasks to a highly significant extent inside the work unit. However, the NC program improvement and

EXHIBIT 8.12a: Indirect Manufacturing Indicators: Tayloristic types

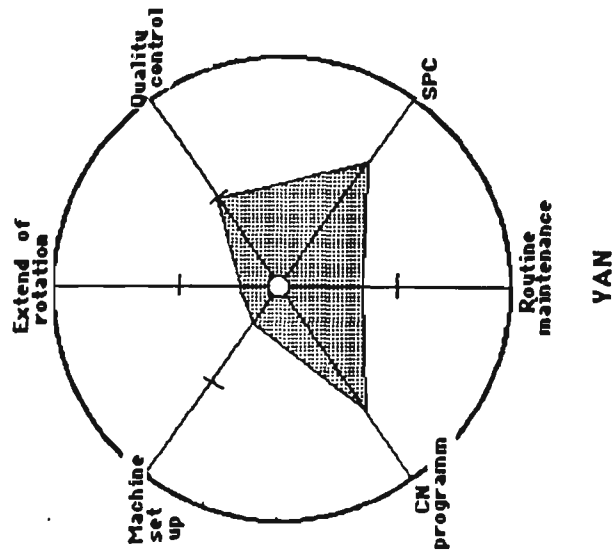




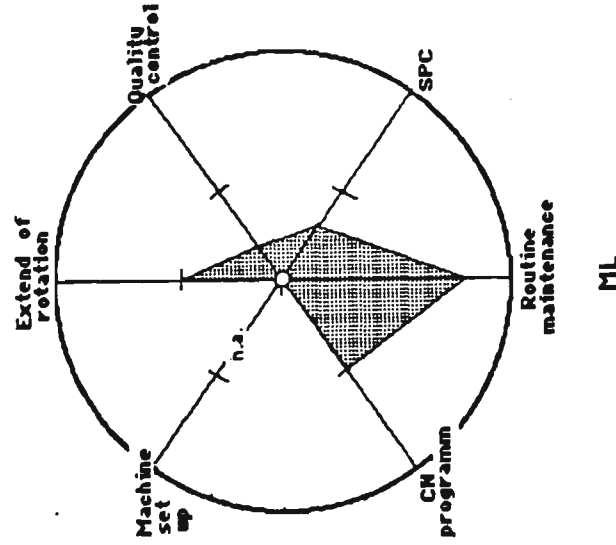
SIE



OSA



YAN



ML

EXHIBIT 8.12b: Indirect Manufacturing Indicators:
Low level of human-centredness

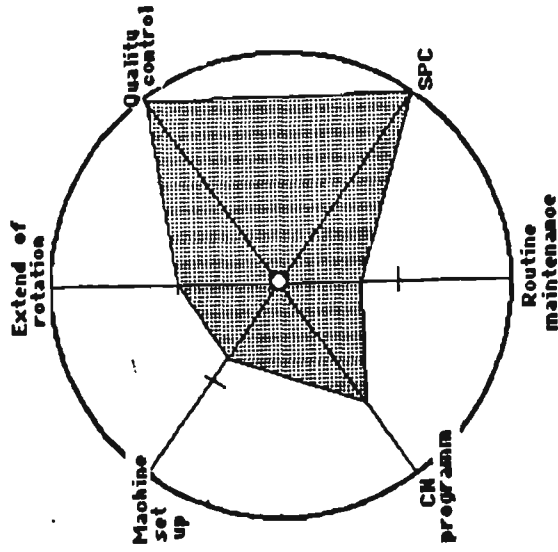
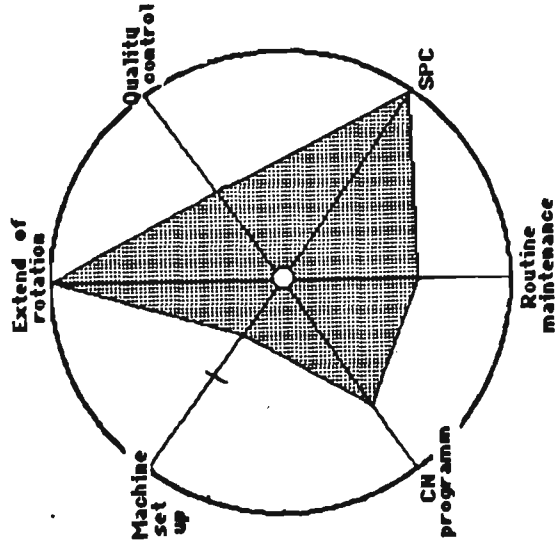
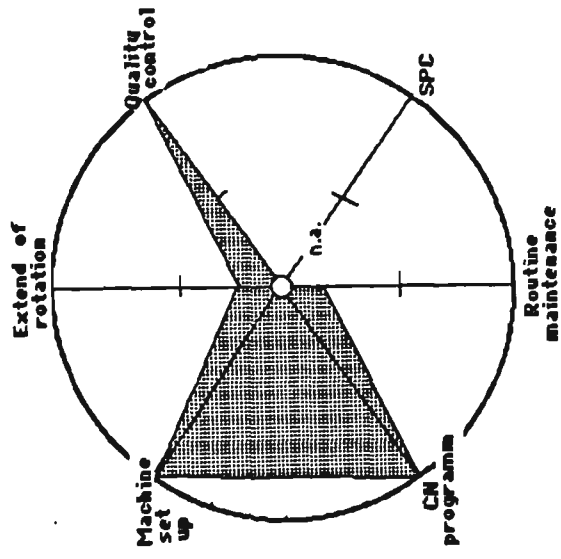


EXHIBIT 8.12c: Indirect Manufacturing Indicators:
Medium/high levels of human-centredness

machine tool set-up activities were performed by specialised personnel. That is, the two latter items continued to be organised along traditional tayloristic lines. An important reason for this was the lack of skilled personnel to perform these activities. A similar trend occurred at 'osa' despite their most significant manufacturing operations being assembly activities and not machining²¹⁸. 'Osa' possesses a high level of human centredness for quality control, SPC and a medium level of HC for the 'extent of rotation' indicator. As in the case of taylorist work structures, the extent of rotation was limited because of the lack of skilled personnel to work at different machines/work stations.

Second, no pattern of preferred indicator implementation was found. That is, heterogeneous configurations predominate (see Exhibit 8.12b). It needs to be remembered that the extent of implementation of HC principles for the indirect manufacturing indicators group is simply not related to management willingness and operator skill, but also to the firms' technical limitations. Different products call for different technical needs in terms of SPC, quality control, routine maintenance and so forth. All factors are important, but different firms give them different priorities according to their technical needs and existing skills endowment. Firms implement SPC, for example, only if it will contribute to enhancing product quality, reliability or scrap minimisation. As different firms possess different manufacturing strategies and, hence, different manufacturing performance objectives (in terms of, quality, cost, delivery time, accuracy), they give higher priority to restructuring one indicator rather than another. For example, if a firm does not have quality problems but needs to reduce its scrap percentage, then it will adopt a higher level of human-centredness at, say, SPC indicators but not in quality control indicators as they regard the latter as functioning well. In summary, it seems to be that firms introduce restructuring solely in those factors which are crucial for their short term effectiveness.

Exhibit 8.12c displays the work structure of plants which have introduced manufacturing organisational changes along HC principles. As in the previous case, plant work structures possess different configurations. It seems that firms have adopted HC principles to a significant extent in items they think are crucial for the success of their manufacturing activities (different firms producing different products possess different 'crucial' activities).

Differently to direct manufacturing indicators group, only three out of thirteen plants can be considered as possessing a medium level of human-centredness. This finding is surprising as indirect manufacturing indicators seems to be less important than direct manufacturing

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Because they do not use numerical control machine tools (NCMT) in their core productive processes, indicators of machine tool set up and NC program improvements are not applicable.

indicators. This is because, while direct manufacturing indicators involve the transfer of some production planning and controlling activities from the PPC department to workers directly on the shopfloor, indirect manufacturing indicators involve only the transfer of indirect activities from indirect shopfloor workers to direct shopfloor workers. That is, from the power relations perspective, direct manufacturing indicators seems to be more important than indirect manufacturing indicators.

Now, a cut across examination of indirect manufacturing indicators in our 3 fold category is made in order to point out the most commonly applied indicators. In this way, it is possible to differentiate those factors in which HC principles were applied to a greater or lesser extent. Quality control, SPC and NC program improvement activities were the indicators most frequently applied. Two tentative explanations for this are: (i) they might bring quick cost-saving results; and (ii) they do not challenge current power relations as did indirect shopfloor activities. Conversely, in another set of indicators, a traditional approach was used. These are, namely, the extent of rotation, routine maintenance and machine tool set up. A significant part of the explanation for non-adoption of HC principles in those indicators seems to be due to the shortage of skilled manpower and management's lack of experience in transferring some non-routine activities to the shopfloor.

The picture of work structures in HC-oriented firms suggests, up to this point, the paradoxical situation in which management has decided to transfer some micro planning and controlling activities to direct workers, but they are not able to perform these activities due to a lack of skills on the shopfloor. An additional unconfirmed explanation for this might be that supervisors and line management constrained the transfer of indirect manufacturing activities to direct workers. The findings suggest lower levels of human-centredness and a greater variation in ways of applying HC principles in the examined indicators. In firms following traditional tayloristic approaches, it was clear that management was not interested in transferring any micro planning or controlling activities from the PPC department to the shopfloor.

The final important point concerns the verification of the reintegration of previously fractionated tasks at the shopfloor level. Even though all indicators were not restructured homogeneously, the fact that operative workers perform, besides their traditional manual activities, other related activities such as quality control, SPC or NC program improvement, shows a departure from previous tayloristic work structures. However, at this stage, it is still too early to come to any conclusion. In order to obtain a larger picture of the organisational restructuring process, it is necessary to look beyond the above examined shopfloor level indicators.

8.4 WIDER ORGANISATION STRUCTURE INDICATORS

While a vertical and horizontal examination of work practices provided significant insights into the work and management practices profile at the shopfloor level, these features need to be supplemented by a study of the firm's organisational structure. Thus, the present section aims to find out if the sampled firm's organisational structure was arranged along HC forms and, if so, to what extent. As such, in the following sub-sections a series of indicators reflecting different dimensions of the firms organisational structure are described and examined. The evidence presented allows us to sustain the argument that HC-type organisational structures were developed in studied firms, despite the low level of human-centredness achieved in some indicators such as participation, reward system and career path reforms. The examination of organisational structures permeating the whole firm is important as they allow us to detect organisational changes and differentiate them from 'process' change which might be temporary.

As commented on in chapter 4, organisational structure encompasses the way people and resources are deployed in an organisation in order to achieve specific institutional goals. Task distribution, co-ordination and control are key components of any organisational structure (Pugh et al, op cit). The latter implies the deploying of work structures, the workflow system, hierarchy, span of control, grouping of tasks, the setting of integrative organisational mechanisms and reward policies (Child, op cit), with a view to accommodating external pressures. These pressures are conditioned by the market target, type of product (in terms of the level of technological intensity and customisation) and labour markets.

To the above dimension it is necessary to add established formal and informal rules and norms and procedures that provide guidelines to distribute, co-ordinate and control tasks. Thus, the organisational structure provides a framework in which decisions are taken, informal communications and power relations occur and different people with different hierarchical and power positions compete to realise both their particular goals and the firm's aims.

It is worth noting, however, that organisational structure *per se* does not possess any direct linkage with organisational effectiveness (Child, op cit). That is, organisational structure is not enough to achieve institutional goals. People who belong to the organisations also need to be motivated and rewarded and performance needs to be measured accurately in order to achieve institutional goals.

The wider organisational structure indicators developed and examined here therefore include a broad range of 6 factors. (i) organisational structure; (ii) skill intensity; (iii) reward system;

(iv) career path structure; (v) training efforts and (vi) participating practices used at the lower hierarchical levels.

(i) **The organisational structure** component encompasses two dimensions of the classical definition of organisational structure, namely, integration and hierarchy.

Integration refers to the establishment of integrative organisational mechanisms such as team work, cross departmental teams or matrix structure. Firms which possess a high task complexity level and highly differentiated tasks, usually, routinely apply integrative organisational mechanisms. Integration of the different tasks is an important feature for firms which possess a greater degree of environmental uncertainty within each sub-section and a greater diversity between them (Lawrence and Lorch, op cit). As suggested in chapter 4, the implementation and use of organisational integrative mechanisms has been considered specially important in the case of firms which apply HC manufacturing practices. These firms, because they act under highly uncertain conditions from the personnel, marketing, production and technology perspective, need to set up reliable integrative organisational mechanisms in order to allow personnel to cope with uncertainties.

Using a 1 to 6 scale, Exhibit 8.13 presents an indicator to measure the extent to which Brazilian firms use integrative organisational mechanisms in both their routine and non-routine operations.

Organisational Integration: Key features	Index
No use of integrative organisational mechanisms	1
Limited use of work group. (eg, work group applied only to selected areas such as product design)	3.5
Routine use of work group (eg, cross-departmental teams)	5
Firm wide restructure by projects, product or customer	6

Exhibit 8.13 Organisational Integration Index

Number of hierarchical levels refers to the number of hierarchical levels that a firm possesses. For practical reasons, in the present research a hierarchical level is defined as a cluster of horizontally similar positions (eg within a section or a department). Additionally, the number of hierarchical levels in a firm is the sum of those similar cluster positions, from shopfloor to CEO.

Woodward's (1965) classical study has pointed out, that a direct relationship exists between the type of production process (eg batch or process industries) and the number of hierarchical levels. The number of hierarchical levels is related to: (i) the extent to which decision-making is delegated; (ii) the extent to which procedures are formalised; and (iii) the extent to which direct supervision is used (Child, op cit). While these relationships are neither direct nor determinant, they provide clues about the key organisational features of batch firms.

In the case of successful large batch firms, the lower the number of hierarchical levels, the higher the likelihood of delegating decision-making, whereas if the number of hierarchical levels is high, the higher the likelihood of formalising administrative procedures and direct supervision on shop floor personnel (Child, op cit).

In the case of small batch firms, Woodward found a small degree of formalisation and a small degree of direct supervision of shopfloor workers. For Woodward, these characteristics are associated with the small number of hierarchical levels observed in small batch firms but are not determinant.

Therefore, because the number of hierarchical levels might be an important indicator of a managerial control strategy in firms that produce in either small or large batch sizes, Woodward's insights are important in highlighting the possible departures in managerial control strategies. That is, the lowering of the number of hierarchical levels in both small and large batch firms might indicate a transition phase from the bureaucratic and centralised model of firm organisation to an output control model. The latter, usually associated with organic (Burns and Stalker, 1961) organisational forms, is a key dimension of HC manufacturing practices.

Exhibit 8.14 shows the relationship between the number of hierarchical levels and the index number. As noted, a premium is put on firms with a small number of hierarchical levels because they support organic administrative forms which is an important feature of the HC model. Because the number of hierarchical levels found varies between 4 and 7, those figures have been matched to index numbers.

Number of hierarchical levels	Index number
7	1
6	2
5	4
4	6

Exhibit 8.14: Hierarchical Level Index

Finally, the organisational structure index is defined as the arithmetic mean of integrative organisational mechanisms index plus the number of hierarchical levels index. Exhibit 8.15 shows the organisational structure index number of each firm.

	Yan	Wor	Ml	Cla	Sie	Osa	Weg	Wab	Vil	Emb
I. integrative mechanism	1	3.5	5	4	6	6	5	6	6	3.5
II. num. hierar. levels	1	2	4	2	6	6	2	6	1	1
Index	1	2.75	4.5	3	6	6	3.5	6	3.5	2.25

Exhibit 8.15: Wider Organisation Structure Index

(ii) Workforce skill profile. There is little doubt that the workforce skill level constitutes a major component of any manufacturing system in which high task uncertainty levels exist. In general terms, the literature (cf OTA, 1989) observed that nations which possess outstanding competitive performance, for example, Japan and Germany, possess a relatively well educated and trained workforce. This implies that educational and training institutions are closely linked with industry needs. It is important to note, however, that different paths were followed by these two nations in acquiring this capability. In both cases skill formation was a result of both a complex national system of industrial relations, training and education and of explicit policies at individual firm level.

In the present research, the basic assumption is that in order to cope with high task uncertainty levels, manpower skills level must be above average. While it is recognised that other important forms of skills exist (eg tacit), in the present study, formal education is taken as an

indicator of skills. The skill factor is represented by the proportion of university graduates, technicians and primary school or unqualified operative personnel existing in each firm. Because batch firms usually possess a wider operative base than process firms do, emphasis was given to the proportion of technicians or personnel who have completed secondary school education. Weights have been allocated subjectively considering that the HC model calls for the existence of a high skill level at shopfloor: 35 % for university graduate personnel; 50 % for technicians or personnel who have completed secondary school and 15 % for personnel whether they have completed primary school or not.

In this way, the composed index puts a premium on existing higher qualifications at shopfloor level and minimises inter-firm differences that exist between firms that both design and manufacture products and firms that only manufacture. The criterion used here minimises the weight of skills in a taylorist type firm. That is to say, the high skill levels of engineers do not obscure the low skill levels of shopfloor operators. It is important to note that variation in the weight allocated did not affect a firm's relative position in this item. Exhibit 8.16 details the empirical data and the corresponding index.

	Yan	Wor	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb
Uni(a) grad.		16.97		9.0	4.0		9.2	20.0	22.3	29.2
Techn		57.5		12.0	14.6		30.0	60.0	49.0	35.7
prim. school		25.03		79.0	81.4		60.8	20.0	28.7	351
Weigh	n. a					n.a.				
35 %		0.59		0.31	0.14		0.32	0.7	0.78	1.02
50 %		2.87		0.6	0.73		1.50	3.0	2.45	1.78
15 %		0.37		1.18	1.22		0.91	0.3	0.43	0.52
Index		3.83		2.09	2.09		2.73	4.0	3.66	3.32

(a) refers to percentage of personnel holding specified qualifications
Index: (firm %) x (given weight)

Exhibit 8.16: Skill Level Index: empirical data

Before proceeding further, it is necessary to make a number of points in regard to the above Exhibit. First, it is clear that formal skills, that is formal education, can not account for the existing stock of knowledge in a firm. Work experience and tacit skills are very difficult to measure and, therefore, difficult to include in any 'objective' indicator.

Second, concerning the proportion of university graduates in the researched firms, it is necessary to distinguish between two types of firms. There are those firms which perform both design and manufacturing activities, and firms which perform only manufacturing activities. In the former, there is a need for a significant number of graduate engineers and technicians. In the latter a smaller number of graduate personnel is needed, compared to operative personnel. To partially overcome this distortion when comparing a firm's skill level, a greater weight has been put on the technician category.

Third, the present indicator does not consider skills that are acquired during daily activities as a consequence of the utilisation of advanced organisational forms. For example, use of multi-functional operators rotating jobs routinely, supports skill acquisition and the enhancement process. Although the skills index does not consider the latter, the job rotation index, for example, captures its extent and therefore the degree of opportunity that exists to further develop in-house tacit skills. Additionally, because skill level is linked to the training system, the skill factor was indirectly analysed when examining this variable.

(iii) Reward system. In a HC context, the prevailing reward system needs to match the high worker expectations and the higher work demand on personnel. This is because HC manufacturing practices call on the use of both mental and manual capabilities of personnel. Moreover, as HC practices imply moving from personal centralised and/or bureaucratic control to output managerial control, the reward system needs to be upgraded as co-operation among shopfloor personnel and between shopfloor personnel and hierarchies is necessary.

In order to measure the extent to which the reward system of the researched firms responds to higher work requirements, three indicators have been used (see Exhibit 8.17).

I. Change of reward system	1: not changed; 1.5: Not changed but plan ready to implement exist; 2: new reward system applied in selected area (e.g. pilot project) ; 4.5: new reward system implemented in significant extend; 6: new reward system fully implemented
II. Wage level	2: below regional average; 3; on the average (regional); 5: above regional average;

III. Reward and performance linkage	1: none; 2: symbolic reward; 2.5: individual price by performance; 5: profit distribution linked to firm performance; 6: profit distribution (group/individual) linked with manufacturing performance
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Exhibit 8.17: Reward System Index

The first indicator, considers whether or not the reward system has been changed to support other HC principles, such as job rotation, team work, participating practices, enhanced training or firm wide organisational restructuring by products or cells. The index number is higher if the reward system was changed to meet personnel motivation that arose when other HC principles were adapted. The second indicator considers, wage levels averages, related to the regional market.

The third indicator provides an idea of the extent to which the reward system is linked to group or individual performance. A greater weight is given when a direct connection exists between increased firm performance (seen as higher profits) and the re-distribution of that surplus among the workforce according to group and individual performance. The final reward index is the simple arithmetic mean of the three above indicators. This index reflect 'supporting' conditions for the realisation of HC type work. Exhibit 8.18 details firms positions²¹⁹.

	Yan	Wor	Ml	Cla	Sie	Osa	Weg	Wab	Vil	Emb
I.	1	1	1	2	4.5	6	1	1.5	1.5	1
II.	3	3	5	3	2	5	3.5	5	3.5	3.5
III.	2.5	2.5	1	1	6	6	5	2	1	1
Index	1.5	1.5	2.3	2	4.16	5.6	3.16	2.8	2	1.8

Exhibit 8.18: Reward Level Index: empirical data

(iv) **Career** component is an important part of the reward factor. The existence of a planned career pattern, at all levels, allowing opportunities for both horizontal and vertical mobility

²¹⁹ It is important to note, that other types of rewards exist and they have not been included in the above. Indirect rewards, such as holiday allowances, home loans, family health insurance, are difficult to standardise amongst the researched firms. This data is treated as qualitative information and included in the discussion section.

according to individual performance as well as the firm's needs, is an important source of employee motivation. That motivation is needed not only to retain an employee in the firm but also to support commitment and co-operation. Further, employee mobilisation through different areas, supports skill acquisition and experience. This also increases opportunities for firms to deploy personnel according to changing market demands.

The career index encompasses two elements. First, the extent to which the established career paths are changed along HC lines. In the case of shopfloor workers this means matching career structure to work type. That is, HC practices that demand, for example, job rotation and multi functionality, must be appropriately reflected in the established career pattern.

The second component refers to evaluation for reward purposes. HC practices support group and individual measurement of work performance, as well as the existence of a direct and clear connection between individual and group performance, wages and careers. In reality, this second component of the index is also part of the general reward system. Exhibit 8.19 summarises the criteria used to allocate weights in those two components.

Item	Index
I. Extent of change of career structure	1: none 2: only evaluation mechanism 3: in transition 4: partially implemented 6: fully implemented
II. Type of evaluation for promotion/wage	2: individual 2.5: by section (but not group work) 4: group 6: group and individual

Exhibit 8.19: Career Path Index

As noted in the above Exhibit, greater weight has been given to firms which have fully implemented re-structured career paths, at all levels (ie senior and middle management as well as direct and indirect shopfloor workers), matching the rewards system with career paths by using tailored work measurement organisational devises. Firms that re-structured partially their career patterns (with its associated payment methods), are assigned a 4, in the 1 to 6 scale. A 3 is assigned in the case of a new career system being implemented at the time of data collection. An index 2 is assigned to the indicators when career structure is not linked to rewards. That is, it might be used, for example, solely as an evaluation mechanism but results

of that evaluation are not connected with promotions and wage changes.

Because it seems that a combination of both individual and group evaluation performance fits well with HC types of work structures, a greater weight has been assigned to job evaluation devises which encompass both individual and group evaluation. That is, HC work structures call for group and individual work performance measurement as it supports both individual commitment and co-operation within the work group. Exhibit 8.20 details empirical data.

	Yan	Wor	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb
I. Extent of career path change	1	1	2	5	3	6	4	5	2.5	1
II. Evaluat ion mechan ism used	2	2	2	3	4	6	2	2	2	2
Index	1.5	1.5	2	4	3.5	6	3	3.5	2.25	1.5

Exhibit 8.20: Career Path Index: empirical data

(v) **Training** is another important component of HC manufacturing theory. The general idea is that production personnel at all levels must possess enough skills to cope with uncertain and complex tasks.

Different ways exist to acquire these skills. Different firms follow different training policies and practices. In the present case, as with previous components, indicators are used only as a measure of formal training. Because the core of work activities can be learned through formal education and on-the-job training (ie sensory-motor and perceptive-cognitive tasks), the training index is representative.

Other forms of training are treated as additional data and considered in the discussion section. That data includes types of subjects taught, number of permanent training staff and on-the-job training practices.

The training index is composed of two indicators. First, the number of training hours per capita per year. Second, the amount of money spent on training per capita per year. These two indicators give an idea of a firm's commitment towards skill acquisition. The amount of money spent on training activities might vary to a significant extent depending on who (which hierarchical level) has been trained; type of course (in-house by an external consultant or by own staff); and where it occurred (eg locally or overseas). Training at higher staff levels, for example, might be expensive and only reach marginally the shopfloor workers. That is, the 'polarisation' problem again may influence our indicators. In order to attempt to avoid that type of distortion with the indicators used, different weights have been allocated to each indicator: 65% to the number of hours training per capita and 35 % to the amount spent in training per capita. Exhibit 8.21 differentiates training indexes by firm.

	Yan	Wor	MI	Cla	Sic	Osa	Weg	Wab	Vil	Emb
Hours per (a) capita	90	70	135	31.4	25.13	na.	63.3	11.6.	114	67.6
Money per (b) capita	100	250	176	54	26.8		174	23.5	34	140
hours index (c)	2.34	1.82	3.51	0.81	0.65		1.64	0.3	2.96	1.75
money index (d)	0.75	1.87	1.32	0.40	0.20		1.3	0.17	0.25	1.05
Index	3.09	3.69	4.83	1.21	0.85		2.94	0.48	3.21	2.8

(a) refers to hour training per capita per year (1992)
(b) refers to money spent in training per capita per year (1992) in \$ US
(c) Hours index weight 65 %; Index 3.9 (out of 6) represent 100%; 150 hours training per capita per year considered maximum value of training per capita.
(d) Money index weight 35 %; Index 2.1 considered 100%; US \$ 280 considered maximum value spend on training.

Exhibit 8.21: Training Index

(iii) **Participation** in HC theory possesses, besides its self-realisation and democratisation aims, a clear instrumental goal. That is participation of direct workers is needed because of their key role in solving 'on-line' manufacturing problems. Planning or organisational design, implementation and routine operation are typical stages where participation of managers, supervisors and direct workers is possible. The goal here however is restricted to knowing the extent to which both supervisory levels (eg foremen) and shopfloor operators possess space to

re-design their tasks at work unit level (eg section). In order to capture this information, two indicators have been developed and applied (See Exhibit 8.22).

index-1	Index-2
1: No intervention	2: organise own tasks: eg, distribute tasks inside group; define with group way to perform tasks;
2: informed before changes	3: organise detailed planing of tasks. eg determine priority order of jobs; possess some control of when to perform different jobs;
3: consulted before changes	4: co-ordination tasks. eg, relate with other sections; preparatory tasks; seek information, etc.;
4: some input (voice) in changes	5: elect group leader;
6: relative wide input (voice) in changes at any level	6: execute routinely supervisory functions of its own job like work performance. and quality control activities.

Exhibit 8.22: Participation Index

The first indicator, attempts to measure the level of intervention by managers, supervisors and operative personnel at planning, implementation and routine operation stages. Because shopfloor personnel input at these stages represents a real departure from traditional managerial practices, greater weight has been assigned to shopfloor personnel input at those stages (50%) and a lesser weight assigned to both management and supervisory levels (25 % each one), as they traditionally provide higher input at those stages.

The second indicator refers to the extent to which the supervisor and shopfloor operators are able to organise their own immediate work environment. This involves the organisation of tasks to perform, detailed production planning, co-ordination of functions, and the entitlement to elect group leaders and execute supervision functions (Gulowsen, 1979). As in the previous cases, 1 denotes non or very low occurrence of the variable refer to and 6, a high occurrence. Exhibits 8.23a, 8.23b and 8.23c details empirical data as well as its associated index.

	Yan	Wor	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb
	P I O	P I O	P I O	P I O	P I O	P I O	P I O	P I O	P I O	P I O
Mgmt.	6 6 1	6 6 1	6 2 6	6 4 2	6 6 2	6 5 6	5 6 1	4 2 6	6 6 1	6 5 3.5
Frm.	4 2 4	4 2 4	4 2 1	4 2 1	3 2 1	6 6 6	6 6 6	6 6 6	4 4 4	4.5 3.5 4

Oper.	2 2 1	2 2 1	2 4 4	1 5 4	5 5 6	1 4 5	2 4 4	6 6 6	1 1 2	5 2.5 2
Averg.	4 3.3 2	4 2.6 2	4 2.6 3.6	3.6 3.6 2.3	4.6 4.3 3	4.3 5 5.6	4.3 5.3 3.6	5.3 4.6 6	3.6 3.6 2.3	5.16 3.6 3.16
%	1 2.7 1	1 .66 1	1 .65 1.8	.9 .9 1.15	1.15 1 1.5	1 1.25 2.8	1 1.32 1.8	1.32 1.15 3	0.9 0.9 1.15	1.29 0.9 1.58
Index	4.7	2.66	3.45	2.95	3.72	5.13	4.19	5.47	2.95	3.77

P: Planning
I: Implementation
O: Operation activities
%: Relative weight assigned to planning (25%),
implementation (25%) and operation (50%)
activities.
Index = (%P + %I + %O)

Mgmt: Management
Frm: Foreman
Oper. Operations
Averg: Average

Exhibit 8.23a: Participation Index-1: empirical data

	Yan	Wor	Ml	Cla	Sie	Osa	Weg	Wab	Vil	Emb
	S O	S O	S O	S O	S O	S O	S O	S O	S O	S O
Org tasks	-- 6	-- 3	-- 4	-- 6	-- 6	-- 4	-- 3	-- 6	-- 1	-- 4
Org. detail task	1 3	2 3	6 1	1 1	1 3	1 3	2 3	1 3	2 1	2.5 2.5
Co-ordint.	-- 3	-- 1	-- 1	-- 5	-- 4	-- 5	-- 1	-- 1	-- 3	-- 2
Elect leader	-- 1	-- 1	-- 1	-- 1	-- 3	-- 1	-- 1	-- 1	-- 1	-- 1
Super visory duties	2 1	2 3	6 6	2 1	2 3	2 5	2 1	6 1	2 1	2.5 3

Averg.										
S	1.5	2.0	6.0	1.5	1.5	1.5	2.0	3.5	2.0	2.5
O	2.8	2.2	2.6	2.8	3.8	3.6	1.8	2.4	1.4	2.5
% S	0.3	0.4	1.2	0.3	0.3	0.3	0.4	0.7	0.4	0.5
O	2.24	1.76	2.08	2.24	3.04	2.88	1.44	1.92	1.12	2.3
Index	2.54	2.16	3.28	2.54	3.34	3.18	1.84	2.62	1.52	2.8

S: Supervisor O:Machine operator

% S: 20 O: 80 %

Exhibit 8.23b: Participation Index-2: empirical data

	Yan	Wor	MI	Cla	Sie	Osa	Weg	Wab	Vil	Emb
I	4.7	2.66	3.45	2.95	3.72	5.13	4.19	5.47	2.95	3.76
II	2.54	2.16	3.28	2.54	3.34	3.18	1.84	2.62	1.52	2.5
I+II/2										
Index	3.62	2.41	3.36	2.75	3.53	4.15	3.01	4.04	2.23	3.13

Exhibit 8.23c: Participation Index: empirical data

Before examining these factors, it is worth recognising that, while the above indicators are limited to capturing specific dimensions of 'participation', they are also reliable indicators of the manoeuvrability of shopfloor personnel to self-manage their work.

Wider organisation structure: A Qualitative examination

Based on empirical data the researched firms were divided into three groups. Those in which a lower level of organisational change occurred belong to Group-I. This group may be considered 'traditional' as they have performed only minor changes in this indicator. As such, the extent to which changes occurred was below average (under 3, using the index). Group-II firms are those in which organisational factors were changed to an average extent (ie around 3). These firms can be considered in the 'low level' bracket of HC manufacturing practices implementation. Firms in which the extent of change was above average, belong to Group-III. These may be considered as possessing a 'medium' level of human-centredness in the wider organisational structure indicators.

Exhibit 8.24 differentiates among the firms, the form and extent of change at a wider organisation structure level. In general terms, organisational change in the six selected factors

was not homogeneous. That is, firms implemented selective restructuring starting with those factors which are easy to modify. These factors do not involve significant changes either in power relations or in additional financial expense to the firm.

In order to examine change in selected organisational factors, it is necessary to differentiate *form* of change from *extent* of change. While the former represents those factors chosen by the firm to be changed, the latter represents the degree of change in each of the six selected factors. Organisational restructuring (form and extent) varied from firm to firm. Empirical data shows that while the *form* of change differs among firms, (ie which factors changed), the extent of change, represented by the shadow area in Exhibit 8.24, can be considered homogeneous within each group.

Group-I firms (traditional) possess two features. First, a common form of change did not exist. That is, Group-I firms chose different factors to restructure. It seems that organisational changes performed in Group-I firms were more a response to contingencies than part of a planned strategy of change. Needless to say those organisational structure changes did not affect the current balance of power between different work units.

Second, the extent of change in Group-I firms was below average. This means firms introduced either cosmetic changes or changes which did not affect the prevalent technical, organisational and social status-quo. These firms are considered 'traditional', as changes introduced were marginal and, did not meet a key requirement of the HC model which involves introducing real change at a wider organisational structure level as an integrated package, in addition to technical and organisational changes at shopfloor level.

Group-II firms have marginally performed some change, in wider organisational structure terms and this accounts for their low level of human-centredness. The forms of change in these firms are, in general terms, similar. While there is no apparent reason for this similarity, two observations can be made. Most marginal change was confined to the skills and training profile of the workforce, although occasional modifications were also made to the reward system and career patterns.

In a similar way, the extent of change was also homogeneous. That is, wider organisational factors changed to a medium level (average index number 3). It can be suggested that Group-II firms are in the early stage of implementing HC practices in the 'wider organisation structure' dimension. Another group of firms seemed to be in a 'transitional' phase as wider organisation structure factors were modified to a 'medium' extent, changing their contextual organisational dimensions from traditional to non-tayloristic forms. This holds true for

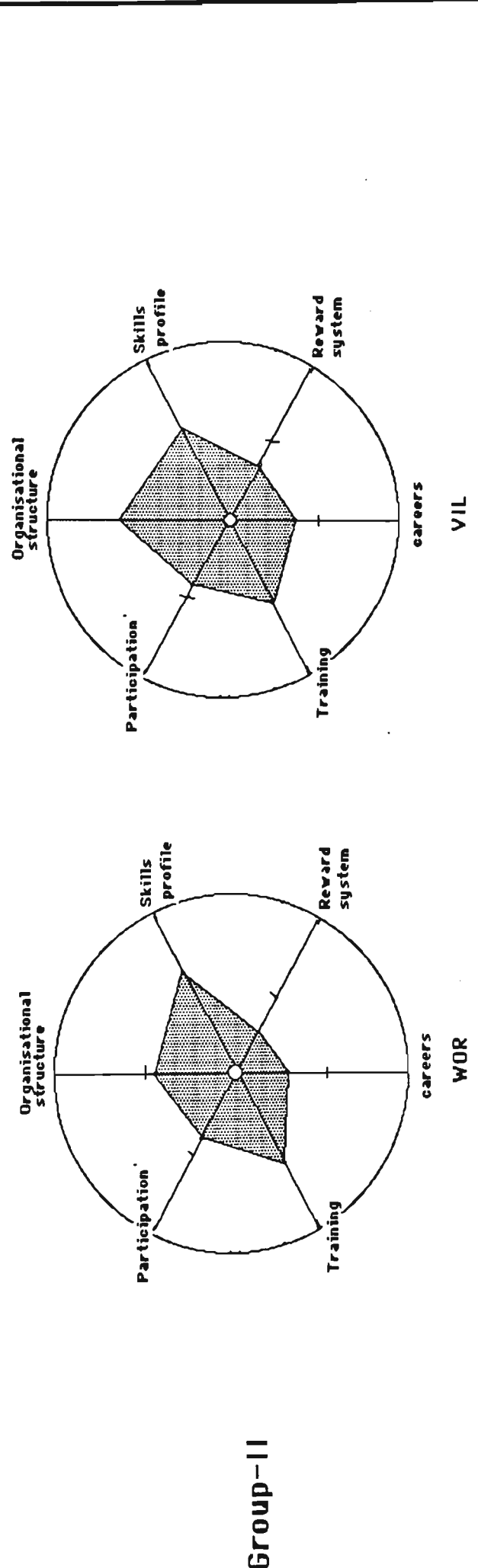
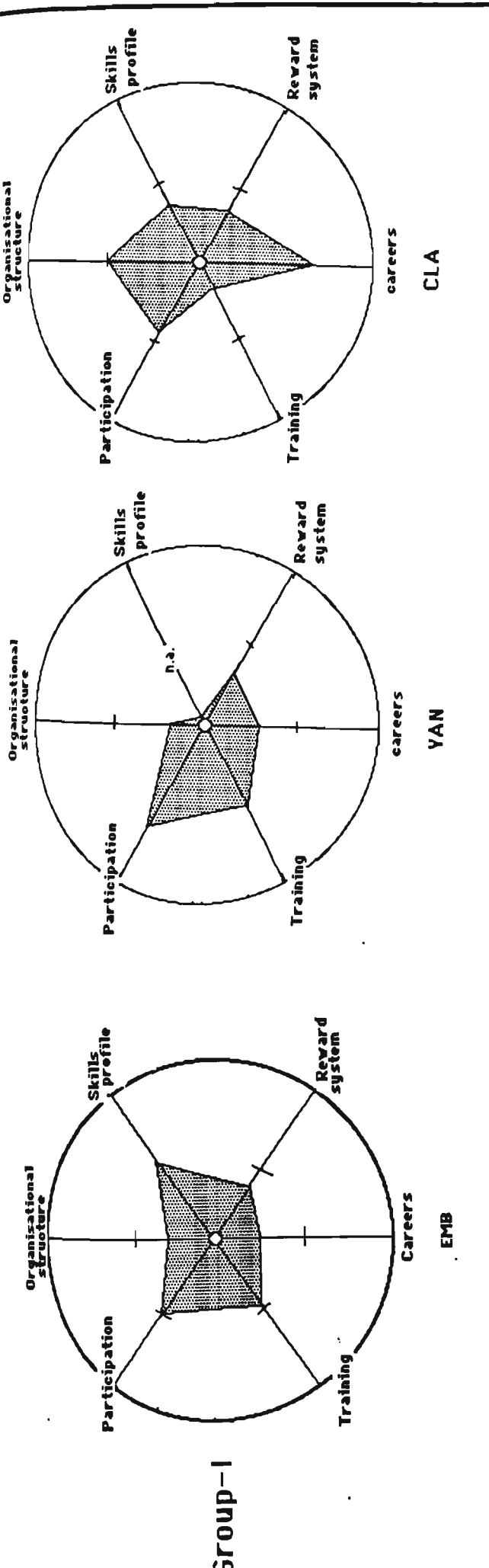


EXHIBIT 8.24: Wider organisational structure indicators: Empirical data

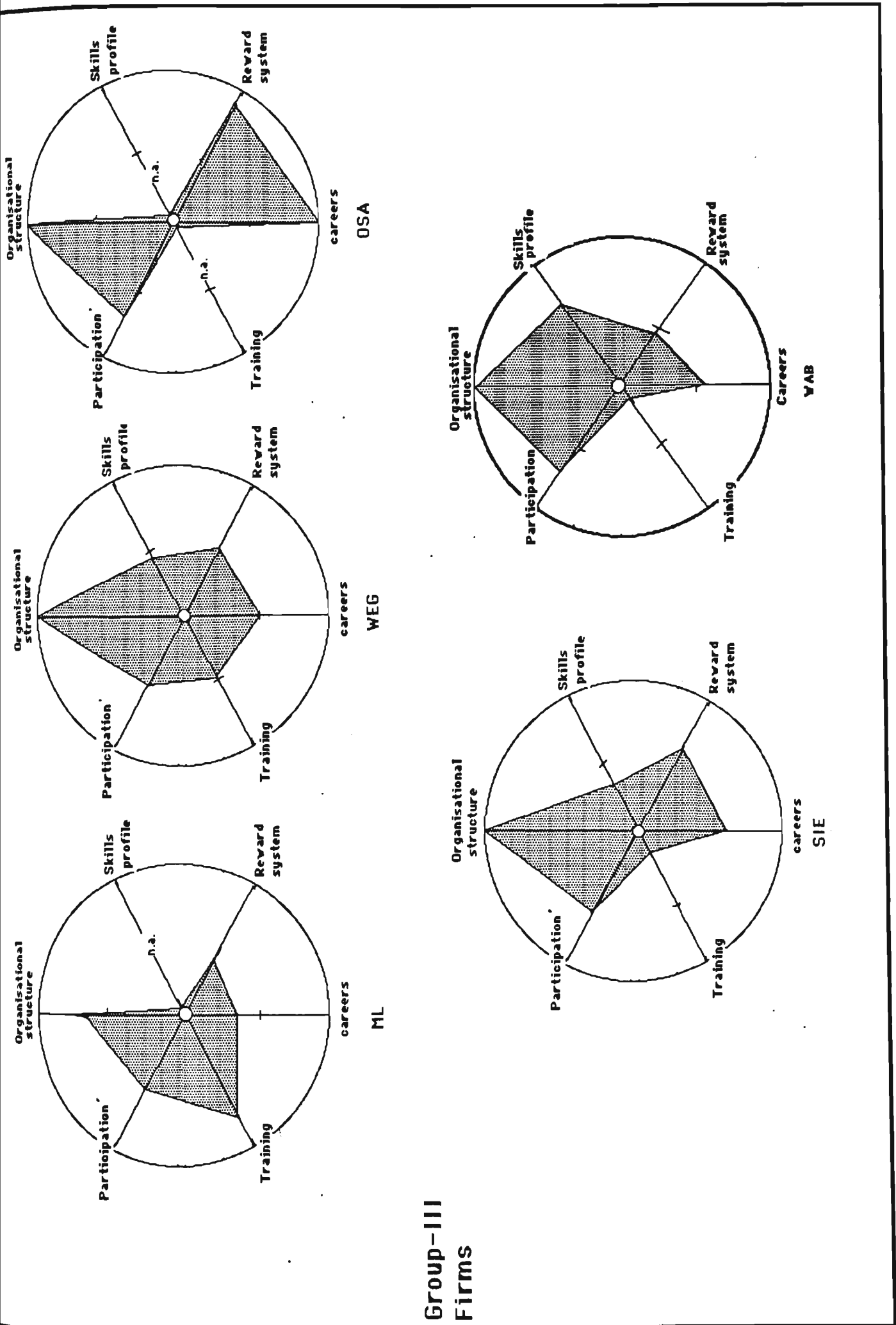


EXHIBIT 8.24: Wider organisational structure indicators: Empirical data

participation, skill and training factors. Nevertheless, the fact that they possess a medium level extent of change (ie index number around 3), does not guarantee real change. A danger exists in that, in some cases, firms would perpetuate their existing *partial* restructuring. That is, change occurred only in selected areas leaving the remaining ones unchanged.

Group-III firms performed deep organisational changes in their wider organisational structure. The form of change was heterogeneous, given the various combinations of factors that firms restructured. Nevertheless, the organisation structure dimension was most frequently and significantly changed by Group III firms. This involved reducing the number of hierarchical levels and firm wide reorganisation of operations including organisational structure 'by product' or 'by customer'. The latter included, for example, the use of inter-departmental group work or committees. Whilst this development indicates a real departure from traditional organisations, its success depended on the extent to which other factors (eg skills and training) were restructured.

The *extent* of change experienced by Group III firms was significant. That is, the size of the shadow area among Group III firms is similar. This indicates that, using different ways of implementation, Group III firms are converging to adopt technical and organisational changes in their wider organisational structure factors. However, it should be noted that no firm adopted HC principles fully.

Moderate levels of *participation*, (ie slightly above the median measure), was is another feature of Group-III firms. This is a curious finding as Brazilian firms traditionally followed tayloristic work structures that, by definition, rule out any worker input in planning, implementing and even the setting-up of routine activities. Moderate levels of participation means that advanced firms are seriously applying (ie not only superficially or as a marketing strategy) participating practices as part of a whole package of restructuring to improve competitiveness²²⁰. Empirical data showed that shopfloor worker participation occurred more in the setting up of their own operative activities and to a marginal extent, during the planning and implementation stages. This selective participatory approach, therefore, can be better interpreted not as participation in organisational design but rather as assuming direct control of work.

The *reward system and career structure* were factors which changed to a lesser extent. Only one firm implemented reward and career factors along HC lines. Three firms in this group

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In the present case, *relative* participation must be understood as a situation in which workers have input in most operational decisions directly affecting their own work and some authority is delegated for some aspects of their work (Cole et al., 1993:68).

were in the process of implementation, or they had already implemented these but, in selected operational areas only. As explained below, domestic macro economic conditions prevented firms implementing deep organisational changes beyond the manufacturing sphere.

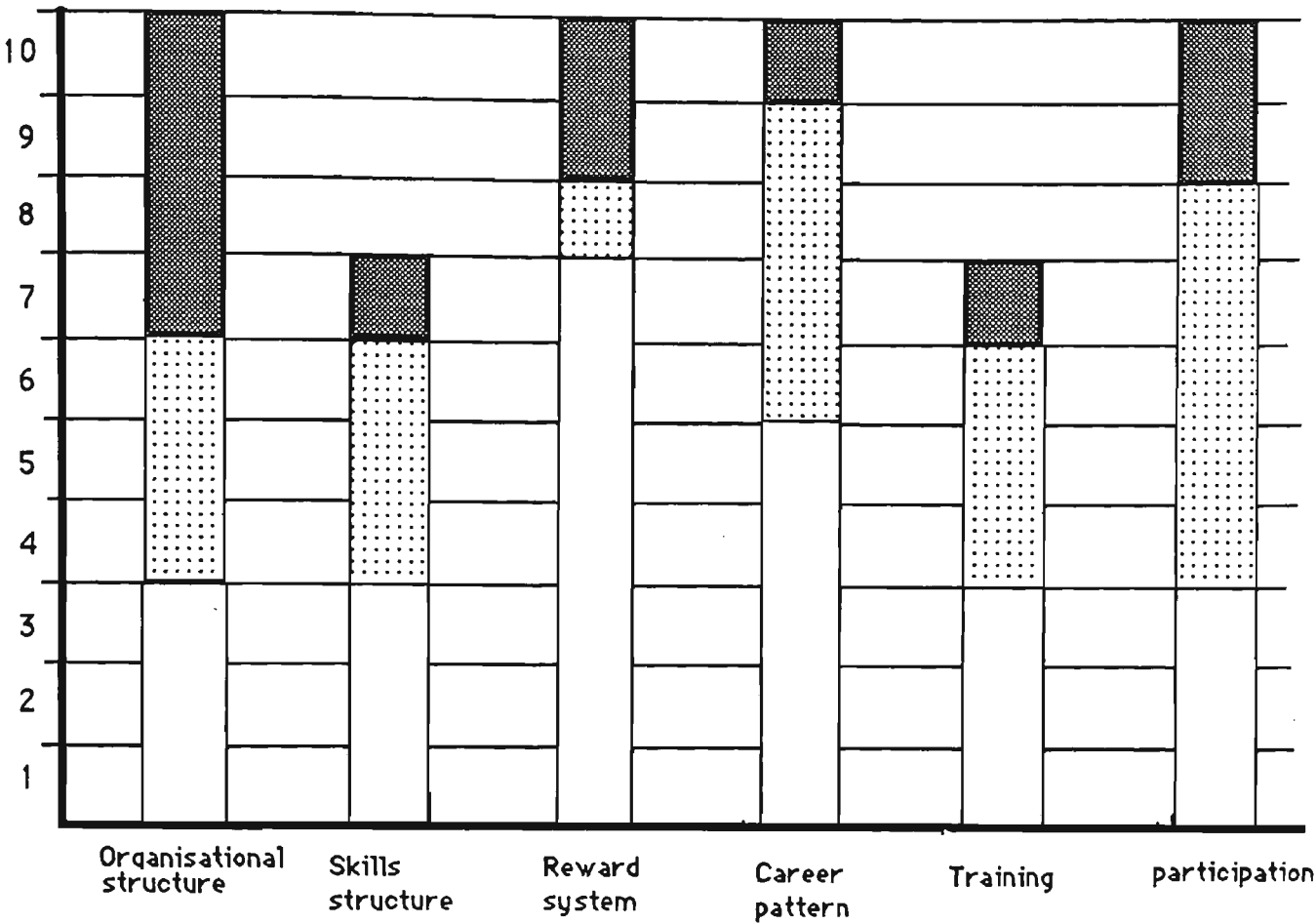
Making an examination of the wider organisational indicators among all researched firms (see Exhibit 8.25), it is possible to observe that in the majority of firms, the reward system and career paths factors continued to be organised along traditional paths. Because changing rewards career paths involved not only the upgrading of wage scales but also changing social and power relations, these changes are usually the last factors to be considered in the restructuring process. Macro contextual factors, such as high unemployment, and hire and fire policies practised by both private and government firms, in part account for the firms reluctance to change wage rewards and career paths.

Conversely, change to the organisational structure factor was promoted to a significant extent. Four firms changed it to a great extent and three changed it moderately. This means that firms were keen to promote organisational changes which did not affect wage scales. Moreover, these changes provided in several cases, justification for dismissals both at shopfloor and middle management levels.

Based on observations of the three last sections, two important points need to be raised. Firstly, while the above examination shed some light to explain possible HC configurations in studied firms, the isolated analysis of each group of indicators does not seem to be adequate enough to provide us with a clear cut picture. To illustrate this point Exhibit 8.26 below shows HC-oriented firms classified according. It can be observed that with the exception of 'wab,' that was present in the three cases, firms labelled as adhering to HC type were all different at the 3 levels of analysis. This suggests that examining solely a selected area (eg, shopfloor, design or firm wide organisational structure) as a means of defining firms restructuring strategies might lead to fundamental evaluation error²²¹.

²²¹ In this event, as asserted in chapter 4, the joint examination of all indicators groups will provide us with an enlarged picture of the problem in order to sharply differentiate the firms which systematically follow HC type restructuring strategies from those firms which do not. This is done in the next chapter.

NUMBER OF
FIRMS






Level of human-centredness		Index number
	High	< 4
	Medium	3=< Index =<4
	non-human-centered	> 3

EXHIBIT 8.25: : Wider organisational structure indicators:
An Aggregate examination

INDICATOR	HC ORIENTED FIRMS
Direct manufacturing	osa, wor1, sie, wab, vil, emb1
Indirect manufacturing	cla, wab, emb1
Wider organisation structure	ml, weg, osa, sie

Exhibit 8.26 HC oriented firms at each indicator Group

Secondly, based on the evidence presented, it can be suggested that all work and organisational dimensions examined are relatively independent in two forms. The extent and degree of human-centredness achieved at the vertical dimension seems to be independent of the extent and degree of human centredness achieved at the horizontal dimension. Furthermore, the extent and degree of human-centredness achieved inside the vertical dimension (ie both shopfloor and firm wide levels) seem also to be independent. Thus, while in theoretical terms its homogeneous application is recommended (cf Noori, 1992), in *praxis* different organisational dimensions are applied in different ways. The findings here suggest a wide range of HC organisational forms.

CHAPTER 9

HCMS IN BRAZIL: SCOPE OF RESTRUCTURING

A significant body of literature exists regarding the use of non-tayloristic work and organisational forms, in European industrialised economies (cf Brodner, 1986; Martin, 1983; Kopacek and Genser, 1990; Kidd and Karwowski, 1994; Koubeck and Karwowski, 1996). However, clear boundaries do not exist between so-called HC manufacturing practices and sociological perspectives of work and industrialisation, such as the flexible specialisation and Japanese lean production approaches. Few attempts have been made to differentiate types (or degrees) of work and organisational restructuring in both quantitative (eg extent of restructuring) and qualitative (eg type of restructuring) terms.

In the present chapter an inter-firm comparison is made to distinguish those firms that restructured along HC principles. After comparing both shopfloor level indicators and shopfloor and firm wide level indicators, it was concluded that the simple 'three group model' used in the previous chapter did not provide enough elements to differentiate between the restructuring strategies. Therefore, new operational criteria were developed and applied to the empirical data for this purpose.

The main argument developed in this chapter is that, due to the multi-dimensional nature of manufacturing systems, individual components of each dimension can be applied independently. Moreover, because of this characteristic of organisational concepts, it is suggested that it is extremely difficult to draw a line to clearly differentiate HC type firms from other types of firms. The level and focus of analysis are important and, therefore, the joint examination of both shopfloor and firm-wide indicators is necessary. This Chapter concludes suggesting that firm level examination is insufficient to properly explain organisational arrangements at the level of the firm. Macro contextual factors, and specially Industrial Relations related matters, seems to further explain developments at the level of the firm.

The configurational feature of manufacturing engineering systems outlined in chapter 4 constitute the theoretical base which informs the empirical examination. It is argued that both technological and organisational components of manufacturing engineering systems possess a configurational nature. That is, they can be independently arranged in a limited number of

ways. Because individual components are socially constructed, they can be deployed in different ways by their designers, developers, implementers and users. This means that individual components (both technological artefacts and organisational concepts/principles) can change over time; they can be interrelated to a higher or lesser extent; and that the nature of the linkage might also change over time, resulting in different arrangements or configurations.

The first section, therefore, combines direct and indirect manufacturing indicators in order to examine changes in work and organisational structure at shopfloor level. The second section associates shopfloor level indicators (direct and indirect manufacturing indicators) and firm wide indicators in an attempt to differentiate HC organisational forms from other forms. The third section jointly examines indicators included in the vertical dimension with the horizontal dimension in order to differentiate the HC-oriented firms of our sample. In section four, both the general guidelines presented in chapter 1 and criteria for human-centredness presented in chapter 4 are tested in order to assess their utility. The last section comments on the relationship between general design orientation and productivity levels. It is concluded that there are no clear productivity consequences derived from applying different design orientations.

9.1 A SHOPFLOOR LEVEL EXAMINATION

This section combines shopfloor level indicators in order to examine different HC configurational forms. This analysis is important to supply information on whether or not a shopfloor level examination is enough to differentiate HC oriented firms from non-HC oriented firms. The argument empirically sustained is that shopfloor level examination is insufficient to differentiate HC type firms from others. Exhibit 9.1 shows plants classified as HC oriented for both direct and indirect manufacturing indicators. Two types of firms/plants were differentiated.

Type 1 firms (weg, wor2, emb2 and emb3) possess a low degree of Human-centredness for both direct and indirect manufacturing indicators. Firms in this group are clearly pursuing work and production organisation along traditional tayloristic lines.

In order to understand type-1 firms' strategic choices, it is necessary to look beyond workforce control issues at the firm level. In addition to market forces, a number of factors influence decisions made by management and the workforce, including: the regional socio-economic and political conditions such as the labour market situation; the different degrees of technical expertise available; the existing vocational training by public and private institutions;

and the prevalent work ethic inside the specific community or geographical region in which the firm operates. The contrast between the pump manufacturer with the electrical motors producer, helps to clarify these points .

The *electrical motor constructor (weg)*, despite successfully applying the latest managerial techniques such as TQM with its associated organisational tools, was classified in Group I due to the fact that those techniques were implanted only at higher and middle managerial levels. Tayloristic work and production organisation strategies were applied at shopfloor level. Other issues that accompanied a tayloristic strategy at the shopfloor, were the keys for maintaining the firm's competitiveness.

First, modern managerial practices were used at high and middle hierarchical levels. There was a systematic use of interdepartmental committees to make 'consensus' decisions about work. This organisational integrator mechanism allowed not only effective communication channels through different managerial levels, but also decentralised the decision-making process, while maintaining centralised key decisions at top level management. Second, the implicit job stability policy accompanied by an above average private firm welfare system (ie profit distribution, strong internal training opportunities and structured career paths) applied by 'weg' help to explain their positive economic performance (see section 5). Third, the firm is located in a small city far from any large industrialised area, so trade union action was weak and disorganised.

Therefore, although shopfloor work structures and production practices were organised along traditional strategies, it seems that, in the case of this particular firm, the co-existence of modern managerial practices at middle/high management levels with tayloristic work structures at shopfloor level, was feasible. The principal reason for this was related to key feature of the Brazilian labour market: low wages and high unemployment levels.

The *pump manufacturer (wor)*²²² contrasts to a significant extent with the above case. Here, it seems that traditional managerial practices were applied for very different reasons. The firm was located in a non-industrial area, where an over-supply of manpower existed and where (as declared by one manager) the employee work ethic was low. Traditional hire and fire practices were used by this firm. Work and production organisation practices were organised along traditional tayloristic views. The firm's competitive advantage comes mainly from their world class product development activities which are located at their headquarters. Therefore, it

²²² In this case, we are referring specifically to the Wor2 plant, which is organised by function. A significant extent of Wor's manufacturing operations is performed in this plant (see section chapter 5 for details).

seems that this firm applies traditional strategies at shopfloor level because their strong competitive stance (in the domestic market) comes from the quality of their product development.

Case studies indicate that firms develop their potential competitive advantage selectively, depending not only on their internal managerial hierarchical decision, but also on their external market position and socio-political environment. The latter influences the personnel's work motivation, attitudes and expectations. This is an important element to deal with in order to achieve manufacturing effectiveness.

Besides this, the empirical data shows that usually firms do not homogeneously apply (across the firm) work and production organisation strategies. As the case of the electrical motor producer showed, they apply very different work and production organisation practices. This was confirmed by the pump producer which applied highly differentiated work and production organisation strategies in their manufacturing cell facilities.

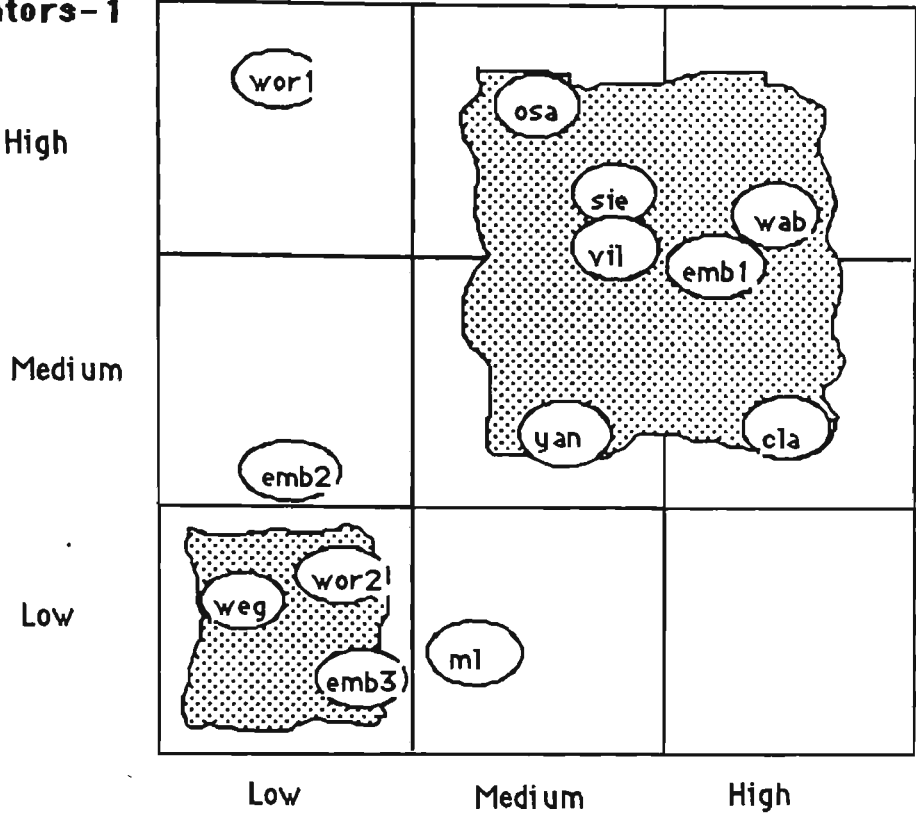
Type II firms (osa, sie, yan, emb1, cla and wab) possessed a medium to high degree of human-centredness for direct and indirect manufacturing indicators. Nevertheless, a wide variety of arrangements were found at each indicator group. Only two firms, 'wab' and 'yan', seemed to possess a balanced degree of Human-centredness in organisational terms.

The cases of 'Osa' and 'cla' illustrate contrasting situations. Osa's direct manufacturing indicators showed a higher degree of human-centredness than the indirect manufacturing indicators. Conversely, cla's features in terms of direct manufacturing indicators were not as well developed as their features in terms of indirect manufacturing indicators. These examples suggest that: (i) organisational strategies applied in both direct and indirect manufacturing indicators terms are quite independent (a priori, technical reasons seemed to play a low profile influence in the degree of application of HC principles); (ii) the levels of human-centredness implemented seemed to be connected to the stage of implementation to a significant extent; and (iii) external socio-political contingencies also, seem to be an important role for shaping the final work structure form in both direct and indirect manufacturing indicators terms.

An additional comment is needed regarding the wor1 plant because it was located at an odd position in Exhibit 9.1. It was classified in Group I because it seemed to be applying strategies which did not make sense (in theoretical terms) from the organisational perspective.

The two plants, which belong to this group, are, in reality, parts of a firm which follow a differentiated work and production organisation strategy when compared to other plants of

Manufacturing
organisational
indicators- 1



Manufacturing
organisational
indicators- 2

- emb1 : emb tool & die shop

emb2: emb assembly

emb3: emb machining serie
- wor1 : wor cells

wor2: wor by function

EXHIBIT 9.1: : Comparative Organisational strategies at shopfloor level

the same firm. The case of the pump producer is the first example. As stated above, the pump producer deploys its work and production organisation strategies along traditional tayloristic practices in all their manufacturing activities with the exception of a section in which cell manufacturing concepts are applied. Because it clearly shows how different work and production philosophies can be selectively applied, this is an interesting case. Production organisation activities at cell level were performed by cell operators, who at the same time, continued to perform work and production functions in a highly segmented way. That is, cell operators remained 'specialised' doing only their routine manufacturing activities. But the variety of similar manufacturing activities performed was wider in this case. This partial application of HC principles boosted productivity in this particular section due to the transfer of those production organisation activities (eg co-ordination, fine scheduling, production appointment), from the production and planning department to direct production workers. As one manager stated, cell arrangements save a significant amount of effort for the production planning department and this results in improvements at two levels.

On the one hand, PPC staff tasks, such as shopfloor activities, micro scheduling and controlling, were transferred to shopfloor workers, leaving PPC staff additional time to concentrate on other activities. On the other hand, those transferred micro planning and controlling activities, performed by cell operators efficiently, provided them not only with greater control over how and when to perform their manufacturing activities (that is opening their range of activities), but also led to improved performance output²²³. This was verified in the specific case of the 'wor2' plant (cell layout) even though management applied HC principles at shopfloor level only.

In *general terms*, the comparison of direct and indirect manufacturing indicators, suggests that direct manufacturing factors were deployed in a more advanced way (ie, non-tayloristic) than in the indirect manufacturing factors. This has four implications.

First, introducing direct manufacturing factors, seems to be more important and difficult to introduce than indirect manufacturing factors only. This is because it involves the transfer of some decision-making activities from the PPC department to the shopfloor and, hence, a change of power relations. This represents a fundamental evolution of managerial practices at shopfloor level as, traditionally, management in Brazilian firms apply tayloristic technological, organisational and human resource management logic (cf Humphrey, 1982; Fleury 1983,

223

While figures do not exist, management claimed higher worker performance in product oriented section than at functionally organised sections. The sources of this improved performance comes from: (i) less supervisory levels were needed; (ii) less micro planing and coordination activities PPC staff performed; (iii) lesser amount of scrap and rejections.

1985).

Second, the lower level of human-centredness found at the indirect manufacturing factors, suggests that the firms reforms have not yet been fully realised. At this point, it should be noted that the Brazilian style of implementation of organisational reform is top-down. Line personnel are affected only after high and middle management ranks have been reformed. Additionally, the small number of skilled workers is a real barrier to introducing reform along HC principles. However, this is not the only factor that hinders shopfloor work structure reforms. Management willingness and worker co-operation play an important role.

Third, the low number of factors implemented that supports HC principles at indirect manufacturing factors, means that a high division of labour is still more the norm than the exception. At this level, only the advanced HC cases showed a real commitment towards minimising the division of labour, designed to support self-regulation at micro-level.

Fourth, despite evident connections between factors of direct and indirect manufacturing indicators, their implementation is selective. Both intra firm factors as well as factors which transcend the firm level, influence the extent to which HC principles are implemented. In the case of a manufacturing cell, for example, rotation levels were directly linked to the extent to which line personnel were effectively multifunctional, as well as the extent micro planning and controlling activities were transferred (by management) from office to line personnel. This depended not only on managerial will but also on the availability of quality skilled manpower and outside factors, such as the national/regional industrial relations environment. This point is further discussed in the conclusions.

9.2 A FIRM LEVEL EXAMINATION

This section uses data obtained in the previous chapter and combines it in order to gain insights into the whole firm restructuring rather than restructuring at shopfloor level alone. This is needed as studied firms' organisational configurations can only be observed through a complete analysis of factors involving both the shopfloor and firm level. The argument developed here is that the multi-dimensional and configurational character of manufacturing engineering systems makes a clear cut classification of HC type firms difficult. Shopfloor indicators, therefore, are combined with firm level indicators to illustrate the different forms the application of HC principles may take. Exhibit 9.2 illustrates the extent to which organisational restructuring has occurred, towards Human-centredness, at both shopfloor and firm level.

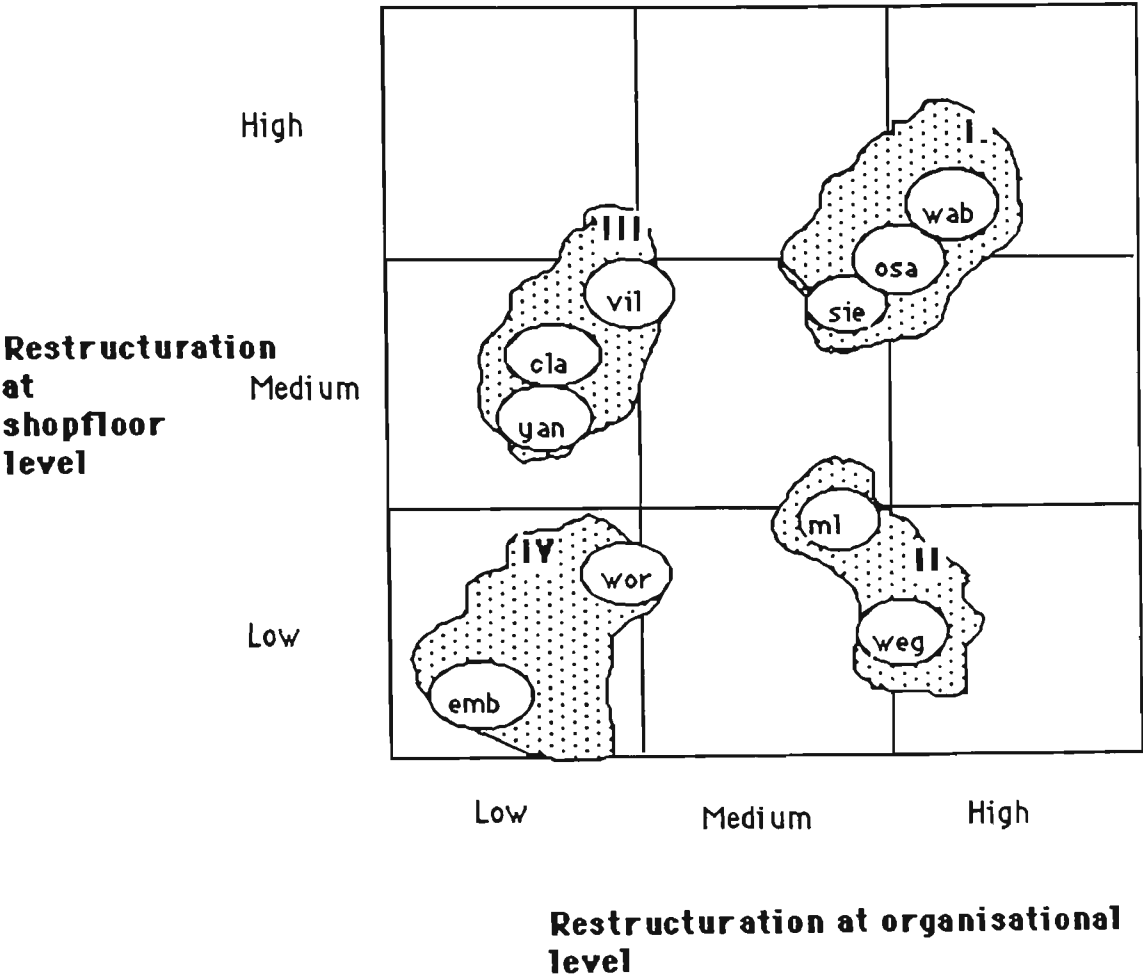


EXHIBIT 9.2: Comparative Organisational strategies at firm level

Two forms of assessment were carried out. First, the number of items that have been changed along HC principles. For example, referring to firm-wide indicators, this item represents how many factors (for example, skills, reward system and participation), have been changed. Complementing the above, the assessment of the extent to which each of the factors have been altered, is the second form of evaluation²²⁴.

Restructuring varied from low to high²²⁵. High, implies decentralised manufacturing operations and labour deployment. At firm level, restructuring might be low or high. High means the existence of an integrated organisational structure (eg use of inter-departmental committees) and differentiated (eg firms structured by product lines or customers rather than by functional specialisation/departmentalisation) at the same time. Low restructuring retains traditional (by function) hierarchical and centralised deployments of shopfloor level manufacturing operations, labour organisation and, at firm level, organisational structures.

Four restructuring strategies were found.

While some firms emphasised the restructuring of firm level organisational structure, others emphasised human resource factors and others preferred to introduce reforms mainly at shopfloor level. In the last case, two indicators were used. Direct manufacturing indicators reflects the extent to which manufacturing operations related to decision-making have been transferred/delegated from PPC department level to shopfloor level. Indirect manufacturing indicators represents some indirect manufacturing operations and reflects the extent to which they are performed by workers

Group I firms have adopted, in general terms, heterogeneous strategies at both the shopfloor and firm level. They have restructured both shopfloor and the wider organisational structures following HC principles. These firms possessed from a medium to high level of human-centredness. However, as Exhibit 9.3 displays, they adopted HC principles differently in terms of factors changed and the extent of change.

Despite possessing high/medium levels of human-centredness, Group I firms have restructured more shopfloor work and organisational structures (ie direct manufacturing indicators) than firm level organisational structure (wider organisation structure indicators). Workers' input in

²²⁴ It is necessary to note that, usually, survey-based studies use solely quantitative indicators which do not inform about profundity of change.

²²⁵ It is necessary to remember that in all cases, solely for simplicity reasons, the degree of a variable is divided into polarised high/low categories. However, real world data is a continuous spectrum between those two extremes.

GROUP I

SHOPFLOOR LEVEL INDICATORS

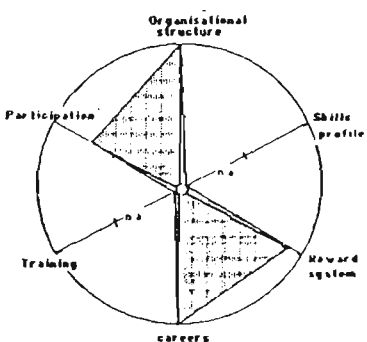
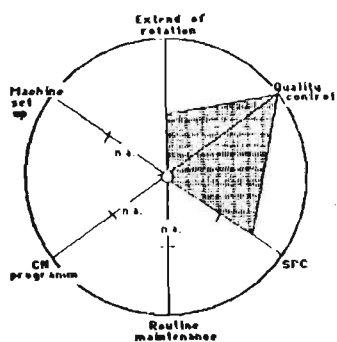
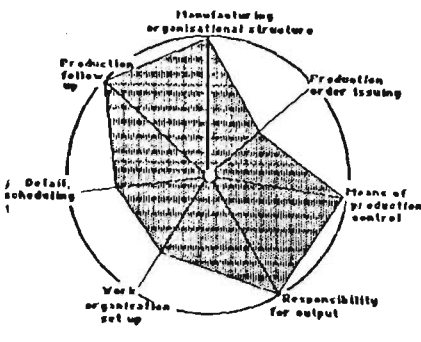
FIRM LEVEL INDICATORS

Org.-indicators-1

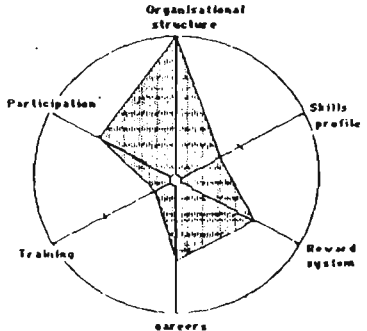
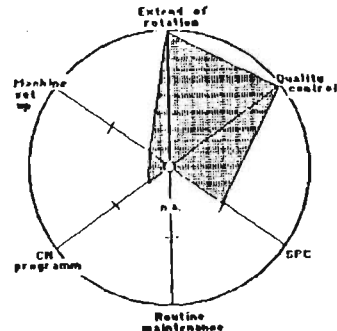
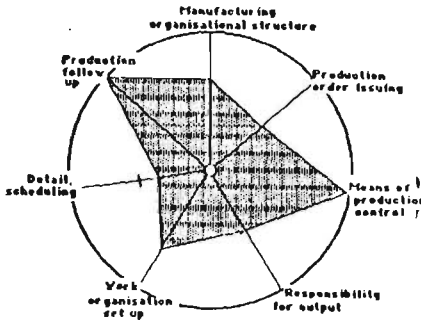
Org.-Indicators-2

Wide-org.-indicators

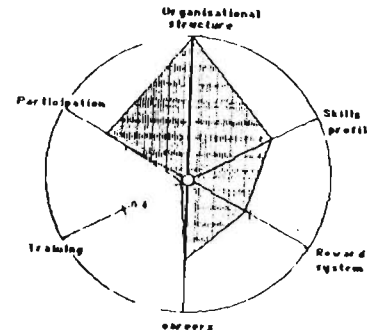
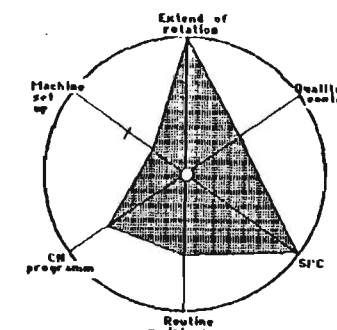
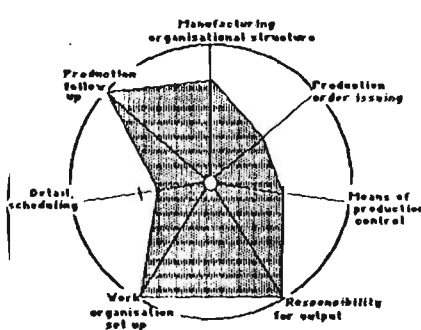
OSA



SIE

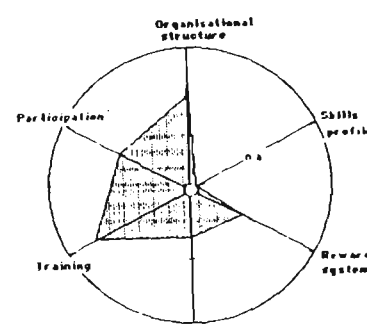
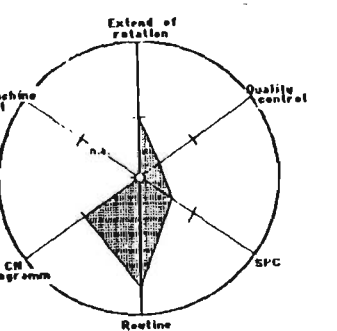
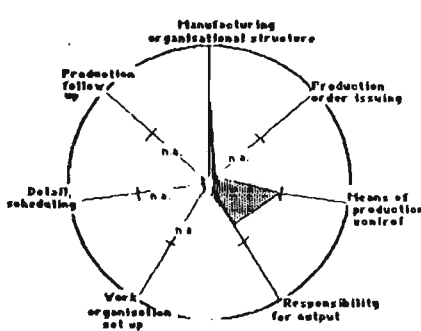


WAB



GROUP II

ML



WEG

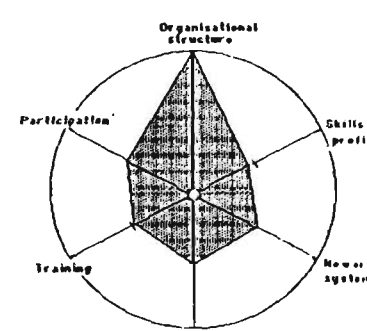
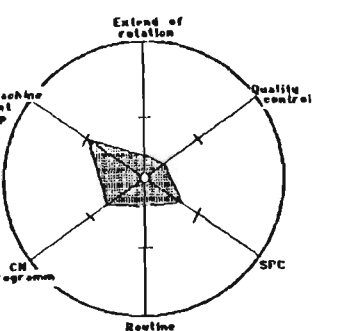
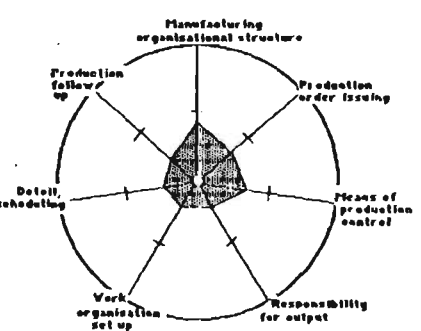


EXHIBIT 9.3: Firms vertical restructuring: empirical data

GROUP
III

SHOPFLOOR LEVEL INDICATORS

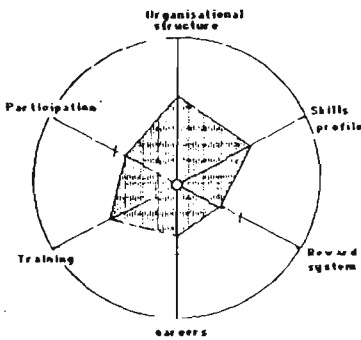
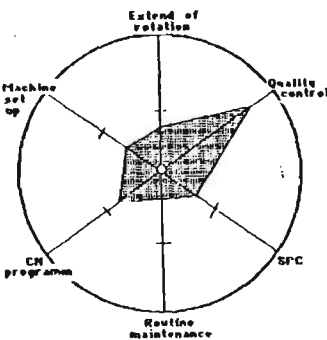
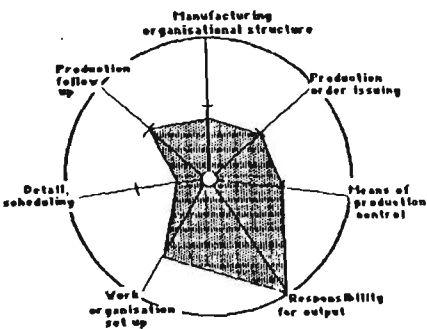
FIRM LEVEL INDICATORS

Org.-indicators-1

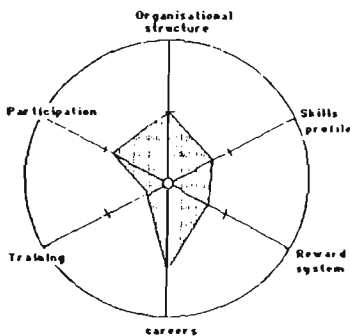
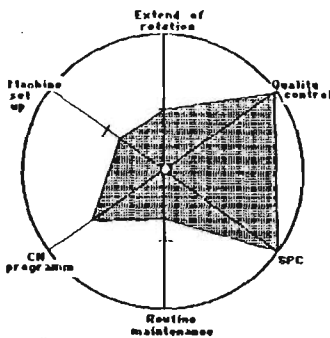
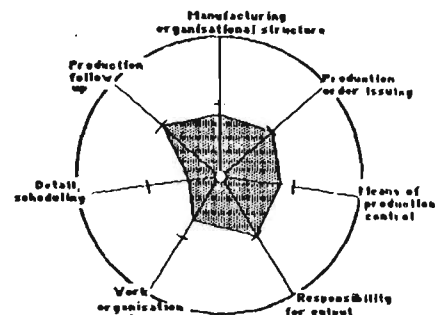
Org.-Indicators-2

Wide-org.-indicators

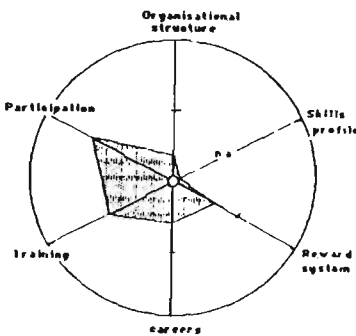
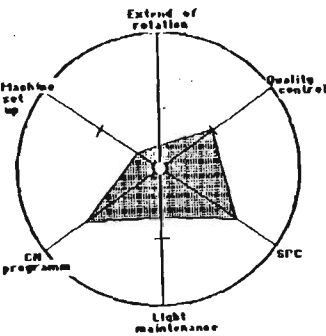
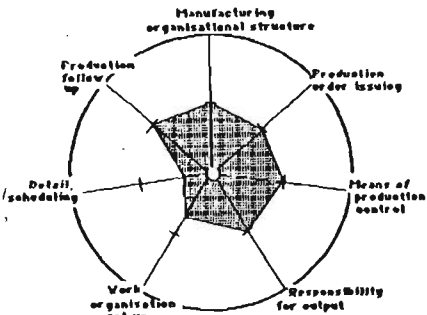
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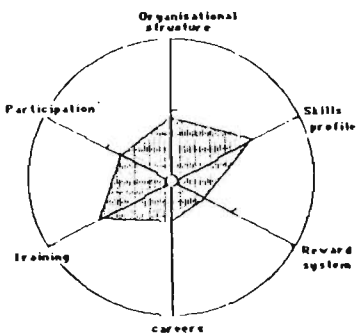
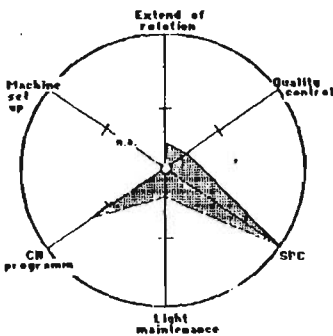
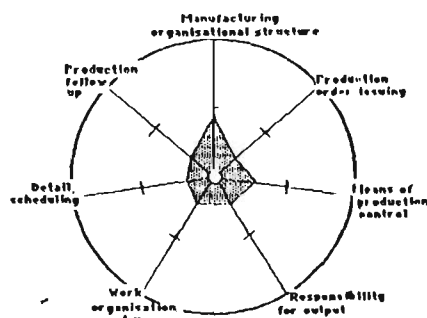


YAN



GROUP
IV

WOR



EMB

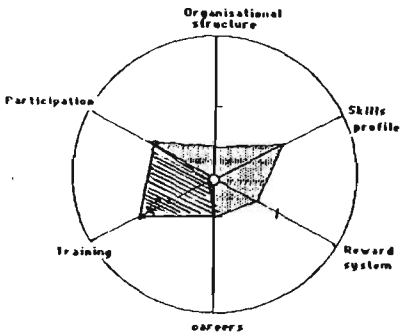
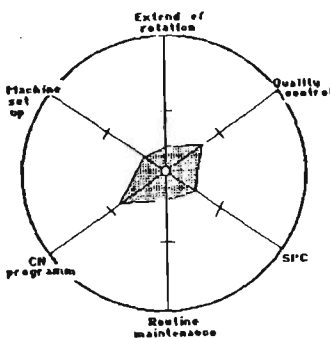
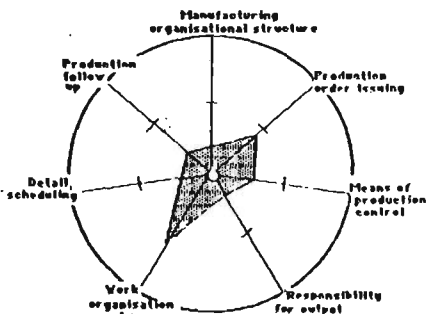


EXHIBIT 9.3: Firms vertical restructuring: empirical data

designing and implementing organisational reforms, however, was low. At the implementation stage, only middle management had input.

The *commercial vehicle brake system* manufacturer (wab), for example, went far in its restructuring process and qualified as HC-oriented when compared to other firms. Even so, it is necessary to note that some key dimensions at shopfloor level such as detail scheduling and machine set up, were deployed in a traditional way. Productive workers were not involved, or were minimally involved, in these activities. At firm level, reform also seems to be in its initial stages. The firm's manufacturing units, however, were restructured by products or customers. Whereas rewards and career and training practices were functioning within traditional lines.

The *automobile plastic parts* producer (osa), implemented HC principles differently. HC principles were applied more at direct manufacturing indicators than at wider organisation structure indicators. That is, the transfer of PPC related decision-making to shopfloor did occur but restructuring at wider organisational indicators (firm organisational level) occurred in a selective way only. It is important to note that indirect manufacturing indicators at both 'osa' and 'sie' were not so relevant for those firms because they do not possess NCMT (osa) or, they do possess them but they are ancillary equipment only.

Group II firms are those in which restructuring occurred to an average extent at firm wide level, but marginally at shopfloor level. In these firms, qualitative restructuring has been implemented at top and middle managerial levels (eg the use of TQM techniques), but other essential firm level restructuring was not implemented. At shopfloor level, those firms displayed traditional (tayloristic) work and organisational structures.

Conversely, in *Group III* firms, significant restructuring has occurred at shopfloor level, but not at the firm wide organisational level. Firms in this group restructured at shopfloor level to a 'medium' extent (ie around index number 3).

Group IV firms are at the other extreme, clearly showing a low level of restructuring at both the shopfloor and firm wide level. Traditional taylorist/fordist work and organisational structures characterise these firms.

In summary, it was observed that the researched firms did not implement restructuring processes homogeneously. Apart from the two cases of human-centredness (Group I) and the taylorist type firms (Group IV), the other firms followed (planned or unplanned, formally or informally) different strategies. Different contingencies and strategies, led firms to adapt HC principles to different extents. From the above conclusions, three implications can be drawn.

First. Regarding other Group II and III firms, it is possible to ask why some firms have restructured more at shopfloor level (eg Group III) while others (eg Group II) have restructured more at firm wide level.

In the case of Group II firms, a clear managerial strategy was observed during the field study. First, restructuring was a top-down process in both firms. They were adapting to modern organisational approaches (such as TQM), that is mainly directed at top and middle management levels. As a result, restructuring at higher and middle management levels was significant in both firms. Second, both firms possess such rigid work structures at shopfloor level that even applying some new organisational forms at this level, such as cellular layouts, labour organisation continues to be deployed under traditional managerial perspectives.

Second, in Group III firms, some organisational changes occurred at shopfloor level but none at firm wide level. This type of restructuring, however, seems to superficially address factors that directly affect shopfloor productivity. International research suggested that this kind of restructuring is short-lived as organisational structures at firm level were designed to support different (eg tayloristic) working conditions (cf Mazjchrak, op cit). Restructuring in these firms meant: (i) mass-dismissals; and (ii) reorganisation of manufacturing operations such techniques as cellular layout and JIT. As a result, shopfloor productivity increased in those firms. The domestic economic recession from 1990 to 1992 triggered the need to restructure shopfloor activities and, at the same time, provided firms with the political bargaining power to effect these mass-dismissals. Workers were not able to fight back due to high unemployment levels. Therefore, it seems that Group III firms introduced selected HC principles only as a 'quick fix' device, to improve productivity.

Third, from the above considerations it can be suggested that an unbalanced application of HC principles at shopfloor level or at firm wide level does not make a HC firm. Conversely, as explained next, cases of selected application of HC principles may result in neo-taylorist cases.

It is concluded from this analysis, therefore, that because the HC concept is multi-dimensional and its individual dimensions can be applied independently, it is too complex to draw a line to differentiate as to whether or not a firm follows HC principles. The unclear position of Groups II and III shows the proposed framework (shopfloor and firm level comparison), does not provide enough elements to clearly differentiate HC from non HC-firms. To assist in solving this problem, an encompassing firm level criteria is proposed next.

9.3 HC RESTRUCTURING: A RE-ASSESSMENT

This section the horizontal dimension is combined with the vertical dimension in order to measure degrees of human-centredness. The horizontal dimension measures the cellularisation process that each firm achieved. Extent of cellularisation process is considered one component of the proposed concept of human-centredness as it seems that operations arranged by cellular concepts support the implementation of HC principles. Even though cellular layouts support the principles, its simple deployment does not guarantee HC principles application. In fact, (neo)tayloristic cellular arrangements do exist.

Because HC principles are multidimensional, configurational and independent, it seems that they can be applied in a wide range of ways at different organisational levels (eg shopfloor and firm-wide). The vertical dimension attempts to capture those different forms and degrees of HC implementation²²⁶. Theoretically, both the horizontal and the vertical dimension must be congruent (ie fit). However, the present examination did not directly focus on the fit/effectiveness relationship as it is a controversial issue²²⁷.

Vertical analysis is composed by three indicators. Firstly, direct manufacturing indicators refers to key PPC related planning and controlling activities that are susceptible to transfer from PPC department to shopfloor level. Secondly, indirect manufacturing indicators refers to some key shopfloor indirect manufacturing activities, such as quality control, and machine tool set-up among others, that are traditionally performed by external specialists. Those indirect manufacturing activities are also susceptible to transfer from external specialists, to production operators. Thirdly, wider organisation structure indicators refer to the extent HC principles

²²⁶ It should be recognised that other operational criteria for differentiating HC oriented firms exist. Aichholzer (1991) for example, proposed an operational criteria based on two dimensions, the scope of restructuring and the degree of technical integration. Scope of restructuring involves the "range of restructuring goals and the relative priority given to restricted cost savings and broader market adaptability..." (p. 283). Integration refers to the degree of technical integration between sub-units. Within these two dimensions possible variations between 'traditional' and 'systemic' rationalisation were detected. While this criteria is important for differentiating between holistic and partial organisational reform, it seems to be lacking as it does not seem to capture nuances that the different forms and extents of restructuring work and organisation structures might possess. Additionally, contrary to Ailchhozer's operational criteria, this present examination grades down the 'technical integration' factor because of the general, medium/low level intensity usage of computerised technology at firm wide level in Brazilian metal-mechanical industry (Ferraz et al, 1992). Rather, the organisational integration factor is considered the important one for this analysis as it is a pre-requirement for technical integration.

²²⁷ See for example Meyer et al, (1993) and Milgrom and John (1993)

have been applied beyond the manufacturing sphere; that is, they evaluate the extent to which factors, which, by their nature, need to be applied firm wide, (eg reward and career systems), have been reformed along HC lines. The vertical analysis is important since this set of indicators reflect the degree to which workers have real input in production related matters, a key dimension of any production system.

Because the direct manufacturing indicators encompasses the transfer of some key planning and controlling manufacturing decision-making from the PPC department level to shopfloor level (direct workers), it is considered important in terms of the acquisition of HC features. Detail scheduling and work organisation set-up, for example, supports workers performing problem solving activities. Detail scheduling is performed much more efficiently at shopfloor level than at PPC department level (Kelley and Lan, 1990). The higher the level of human-centredness in those indicators represents, in general terms, some transfer of decision-making activities such as planing and controlling at shopfloor level.

In the same way, because the application of HC principles in the wider organisation structure indicators encompasses firm wide reform, this group of indicators, are regarded as important. They provide the technical and social systems of production and general infrastructure conditions for the implementation of HC principles at the shopfloor level. At wider organisation structure indicators level, organisational structure, reward and training seem to be the crucial elements. This is because the firm's organisational structure 'by product' or 'customer', for example, favours the focalisation of personnel towards the achievement of concrete goals to satisfy the customer; rewards and training favours personnel with the acquisition of specific skills workers need to support numeric flexibility and job rotation.

Indirect manufacturing indicators examines the extent to which indirect shopfloor manufacturing activities, such as NC program improvement and SPC among others, are performed by direct operators. Besides indirect activities, the extent of rotation indicators seems to be an additional important factor, as it allows working in groups. This is because work rotation supports: (i) manpower numeric flexibility to cope with demand changes; and (ii) workers training as they need to move through the cell coping with different machines/activities.

As observed in chapter 4, the utilisation of the four sets of indicators representing both the horizontal and vertical dimension of the HC concept, allows us to examine whole configurations rather than partial assessments of one variable.

Human-centredness: An Inter-firm comparison

Exhibit 9.4 synthesises our theoretical criteria used to differentiate HC type firms. The vertical axis represents the vertical dimension. Here, three types of restructuring have been differentiated: HC-oriented, neo-taylorist and tayloristic. The horizontal axis represents the horizontal dimension. Here firms were classified according to the degree of cellularisation.

The evidence presented in Exhibit 9.4 points out two issues. First, the vertical dimension seems to be independent from the horizontal dimension since HC-oriented, neo-tayloristic and tayloristic like firms were all found to possess high levels of cellularisation. This means that it is possible to implement HC principles in traditional, techno-centric oriented layouts. The cellularisation process therefore, seems to be an important factor supporting HC implementation but does not constitute a necessary pre-requirement.

Secondly, a variety of alternative organisational forms inside each type exist. Firms that adopted *HC oriented restructuring* are displayed in Exhibit 9.5. These firms adopted, systematically and to a significant extent, HC principles at both horizontal and vertical dimensions. This means individual indicators of human-centredness in both the horizontal and vertical dimensions, ranked from medium to high in these firms. A common feature of firms in this group is that none of them fully applied HC principles. Rather, firms applied HC principles to a higher extent only at horizontal cellularisation indicators and direct manufacturing indicators, while only medium levels of human-centredness occurred for indirect manufacturing indicators and wider organisation structure indicators.

The fact that two firms achieved higher levels of Human-centredness at direct manufacturing indicators is significant, and suggests qualitative changes in the organisation of manufacturing activities are occurring in the Brazilian setting.

In terms of wider organisation structure indicators, no firm achieved high levels of human-centredness. This is not difficult to understand as macro contextual factors existing at the time of data collection, such as the domestic economic recession and political uncertainty, limited, to a significant extent, firms' introduction of deep organisational restructuring areas such as reward and career systems. Even so, in two firms, mechanisms to link work group performance with rewards had been implemented, although not yet fully utilised.

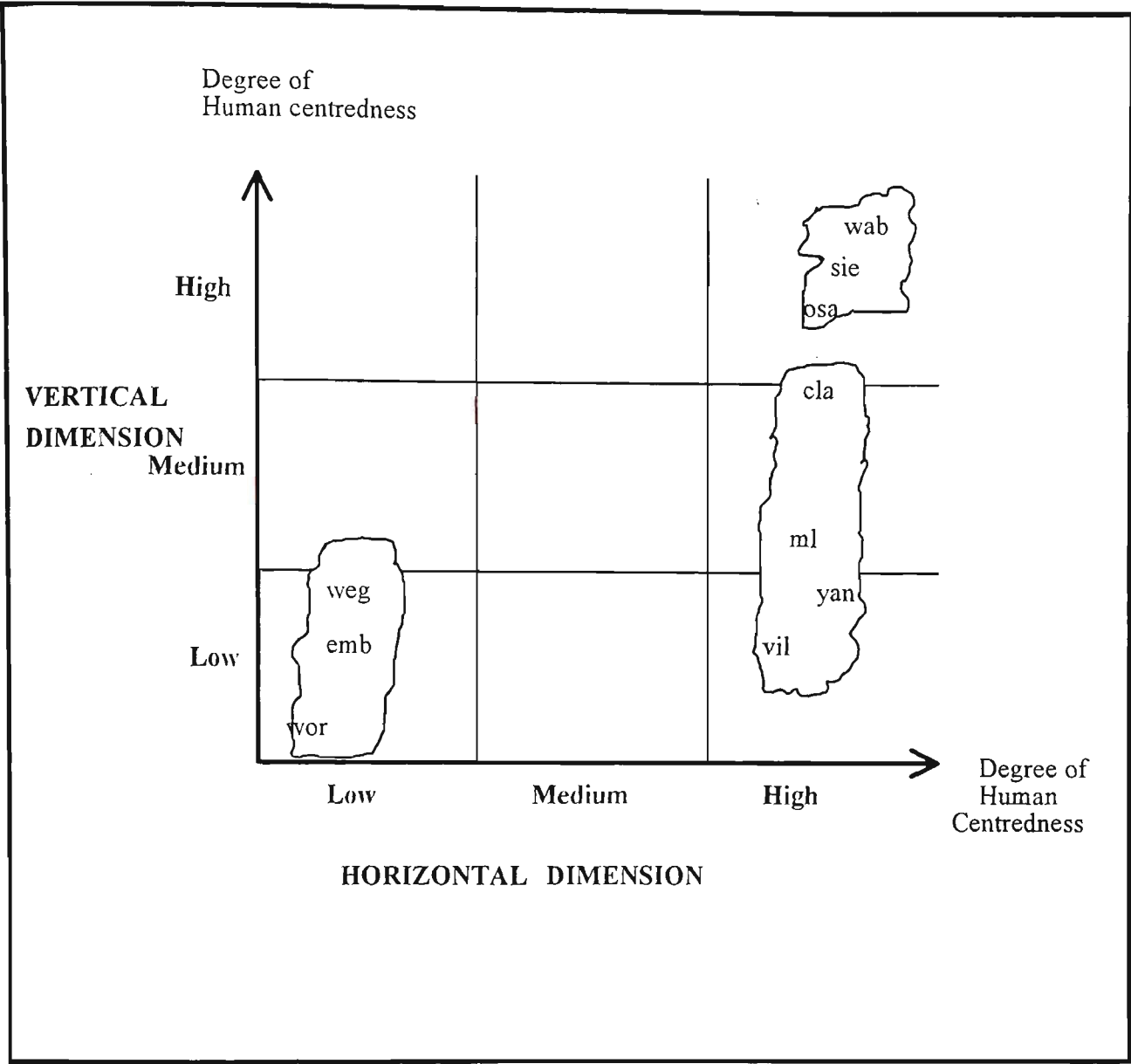














EXHIBIT 9.4: Human centredness: Inter-firm Comparison

Human-centered indicators groups Work and organisational forms	Horizontal cellularisation	Direct Indicators	Indirect Indicators	Wider Indicators
High level of human-centredness	  	 		
Medium level of human-centredness			  	  
Low level of human-centredness				
Tayloristic forms				

 web

 sie

 038

VERTICAL DIMENSION:

DIRECT INDICATORS

- manufacturing Org. structure
- production order issuing
- means of prod. control
- responsibility for output
- work organisation set up
- detail scheduling
- production follow up

INDIRECT INDICATORS

- extent of rotation
- quality control
- SPC
- routine maintenance
- CN programm
- machine set up

WIDER INDICATOR

- firm's org. structure
- skills profile
- rewards
- careers
- training
- worker involvement

HORIZONTAL DIMENSION: Extent firms adopted cellular layouts at shopfloor

EXHIBIT 9.5: Human-centred Oriented Firms

An important feature of firms in this group is the relative uniformity with which they apply HC principles at both the horizontal and vertical dimensions. This suggests a relative congruence between the use of HC work structures at shopfloor level, the intensity of use of cellular layouts and wider organisational structure factors. In theoretical terms, congruence or 'fit' achievement means that technical, organisational and social integration is obtained at once²²⁸. Integration was obtained in this group of firms via the transfer of both micro planning and controlling as well as indirect manufacturing activities from the PPC department or supervisory level to shopfloor operator level, on the one hand, and through the use of mini plants and cell concepts, on the other hand. Additionally, integration was achieved by the responsibility entitlement that shopfloor operator possess regarding results of their own work which involves both manual and decision-making/creative activities. While organisational congruence or fit is regarded by some observers as key to obtaining enterprise effectiveness²²⁹ (cf Morgan, 1986), data was not generated by this study that would support this assertion.

Despite the fact that firms in this group seem to be applying HC principles almost homogeneously, a closer look unravels some variations. At direct manufacturing indicators, for example, 'osa' emphasised detail scheduling performed at shopfloor level (by supervisors), but 'sie' and 'wab' emphasised workers input in the work organisation set up at indirect manufacturing indicators. Different styles were also found in the wider organisation structure indicators. 'Osa' emphasised training and rewards systems restructure along HC principles but 'sie' emphasised changes in the rewards system only. At 'wab', there was no change in the reward and training policies.

Firms that adopted *tayloristic type restructuring* are shown in Exhibit 9.6. These firms have clearly not introduced reform neither at shopfloor level nor at a wider organisation structure level. It should be noted that firms, such as 'weg' and 'wor2', which adopted HC principles selectively, are also included in this group.












In general terms, all firms in this group possess typical tayloristic work structures in both

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Theoretically, organisational fit supports the shopfloor operator's room to re-deploy his/her tasks in order to make 'space' for additional co-ordination and problem solving activities (eg kaisen type activities). This is because operators possess: responsibility for their specific tasks (ie produce 'x' amount of parts by 'd' due date); and technical layout which favours a quick solution of any unexpected trouble and the self-regulation (micro planning and control activities) of the immediate reality of work. The possibility of maintaining social contact with colleagues, the psychological rewards of 'controlling' the immediate reality of work and the attainment of fair economic rewards according to work performed, seem to be a pre-requisite for shopfloor operators to collaborate towards technical and organisational integration.

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There is still an unfinished debate on the fit/performance question. See specially Ketchen, Renner and Snow (1993) and other literature in the special issue of *Academy of Management Journal*, 36(6).

Human-centered indicators groups	Horizontal cellularisation	Direct Indicators	Indirect Indicators	Wider Indicators
High level of human-centredness				
Medium level of human-centredness				
Low level of human-centredness				
Tayloristic forms	 	  	  	

 emb
  weg
  wor

- VERTICAL DIMENSION:
 DIRECT INDICATORS

 - manufacturing Org. structure
 - production order issuing
 - means of prod. control
 - responsibility for output
 - work organisation set up
 - detail scheduling
 - production follow up

INDIRECT INDICATORS

















 - extent of rotation
 - quality control
 - SPC
 - routine maintenance
 - CN programm
 - machine set up

WIDER INDICATOR

 - firm's org. structure
 - skills profile
 - rewards
 - careers
 - training
 - worker involvement

HORIZONTAL DIMENSION: Extent firms adopted cellular layouts at shopfloor

EXHIBIT 9.6: Tayloristic Oriented Firms

Human-centered indicators groups Work and organisational forms	Horizontal cellularisation	Direct Indicators	Indirect Indicators	Wider Indicators
High level of human-centredness	   			
Medium level of human-centredness		 		
Low level of human-centredness			 	
Tayloristic forms				 

 ml

 yan

 cla

 vil

VERTICAL DIMENSION:

DIRECT INDICATORS

- manufacturing Org. structure
- production order issuing
- means of prod. control
- responsibility for output
- work organisation set up
- detail scheduling
- production follow up

INDIRECT INDICATORS

- extent of rotation
- quality control
- SPC
- routine maintenance
- CN programm
- machine set up

WIDER INDICATOR

- firm's org. structure
- skills profile
- rewards
- careers
- training
- worker involvement

HORIZONTAL DIMENSION: Extent firms adopted cellular layouts at shopfloor

EXHIBIT 9.7: Neo-tayloristic Oriented Firms

horizontal and vertical terms. However, it is interesting to comment further on the 'weg' case. Weg possess, as do other firms in this group, tayloristic work structures profile in part of the vertical dimension, (direct and indirect manufacturing indicators) but a high degree of human-centredness at wider organisation structure indicators. This means that at 'weg', tayloristic work structures at shopfloor level (direct and indirect manufacturing indicators), coexist with a medium degree of human-centredness at the wider organisation structure indicators level. In effect, 'weg' possesses a middle/top management organisational structure characterised by the regular use of integrative organisational devices (inter-departmental committees in this case) and a scheme of profit distribution. It seems that modernisation has reached only middle/top managerial levels while shopfloor manufacturing activities remain unaltered except for a profit distribution scheme. However, there are two setbacks in this partial approach. First, while modernisation of middle/top management organisational structure provides firms with a consensus approach to reach managerial decisions, that approach is limited to middle and top managerial ranks. Shopfloor personnel continue to be excluded from performing any decision-making activities related to their own work.

Like in the case of HC-oriented firms, an apparent fit also exists between the horizontal and vertical dimensions (ie, direct and indirect manufacturing indicators and wider organisation structure indicators). That is, firms have adopted a relative uniform approach towards work and organisational deployments, in this case, along tayloristic lines, at both shopfloor and firm wide level. Additionally, tayloristic type firms seem to possess a relative fit in both technical and organisational terms, as long as its associated social control system (ie tight supervision and bureaucratic procedures) function well. Social integration however, was not achieved due to its authoritarian approach in deploying technical and organisational processes.

Firms that applied *neo-taylorist type restructuring* are displayed in Exhibit 9.7. They adapted different restructuring strategies at different levels. Neo-tayloristic type firms therefore achieved simultaneously, high levels of human-centredness at both the horizontal dimension and indirect manufacturing indicators of the vertical dimension on the one hand, and low level of human-centredness or tayloristic strategies at direct manufacturing indicators group and wider organisational indicators of the vertical dimension. In general terms, despite applying selectively HC principles, the prevalent pattern still was closer to tayloristic work structures.

Congruence between the examined vertical and horizontal dimensions does not seem to exist. Theoretically, this may constrain firm effectiveness. However, as empirical data did not focus on this issue, nothing can be asserted regarding the achieved degree of congruence and the firms performance.

Restructuring of firms operations, however, seemed to work quite well without introducing qualitative changes at the wider organisational indicators. In order to understand this, it is necessary to consider the general macro environment existing at that time. Tight labour markets, the domestic economic recession and the application of liberal type industry policies, were the main features of the macro environment. To the traditional high unemployment level, even larger numbers were added due to the 're-structure wave' that occurred in firms between 1991 and 1992. That, 'restructuring' was the reason given to justify to mass dismissals as a means to improve productivity. What is open to question, however, is the life span of organisation changes performed at the manufacturing level, without the corresponding wider organisational restructuring (cf Wilkinson and Oliver, 1988).

Therefore, it has been observed that different approaches were applied simultaneously to different degrees in the horizontal and vertical dimensions. Macro contextual factors, for example, seem to play an important role which 'enforces' the needed social integration at shopfloor level. The high unemployment levels which exist in Brazil make a strong argument for shopfloor workers to 'collaborate', independently of good or bad working conditions. Furthermore, the slightly above average wages that 'ml' pays is another excellent reason for workers to accept managerial rule. In effect, as wages are low in Brazil, even a small difference in wages represents an important reason for shopfloor workers to try to maintain their job (this argument is further explained in Chapter 10).

It is interesting to note that, within neo-tayloristic firms, some are using 'Japanese' manufacturing strategies. That is, they applied of HC principles *only* at horizontal and selected factors of indirect manufacturing indicators. Those firms have adapted, to a significant extent, a cellular lay-out, internal JIT and transferred indirect manufacturing activities, such as quality control and NC program improvement activities. However, key 'control' factors of the direct manufacturing indicators group, such as micro planing and controlling activities were not included. Rather, those key activities continue to be performed by the PPC department or by supervisory levels.

These are important differences between the so called Japanese and HC approach. Japanese type manufacturing techniques were applied in a highly selective way bringing short term benefits to firms but leaving other factors unaltered, meaning that direct workers did not receive much gain from this reform strategy. This is a common research finding. Brazilian data (cf Posthuma, 1994; Humphrey, 1994; Meyer-Stemmer et al, 1992) and experiences in industrialised nations (cf, Oliver and Wilkinson, 1988) have pointed out the lack of association between the Japanese style of manufacturing practices and the use of Japanese style personnel practices.

While the Japanese manufacturing system seems (at least in the form they are applied in Brazil) to promote limited work and organisation reform solely at shopfloor level, the HC perspective supports firm wide reform not only at shopfloor level but at all levels. Moreover, it also encompasses the real transfer of indirect manufacturing and some micro-level decision-making activities from the PPC department to shopfloor operator. That transfer allows a relative decoupling of manufacturing activities between work units in order to supply time to direct operators to perform other work related activities such as co-ordination and problem solving without affecting the other work units. In this respect, the buffer configuration between and among work units is the key to decoupling inter-work units' manufacturing activities.

In the light of the case studies presented, two inferences can be made about managerial attitudes. First, it appears that the emphasis of Brazilian management on obtaining productivity gains by increasing direct control has shifted to an emphasis on indirect measures. Second, and following from this, it is evident that management will apply any strategy to achieve this goal. Or to be more precise, management adopts selective principles from various manufacturing strategies.

What has been learned so far, is that qualitative differences exist between HC and non-HC work structures. However, in hybrid cases, the distance that separates these two managerial strategies is very small. Three comments clarify this claim.

First, going from medium to high level restructuring implies substantial changes not only in organisational procedures but also in the power relations involved. The latter might be interpreted as a cultural change. That is, different hierarchical levels need to learn a new way to relate and interact with personnel upstream and downstream. This task is time consuming and involves alteration of social relations. Conflict and friction might arise when implementing change, especially at middle management level as responsibilities are devolved to the shopfloor. In short, change from medium to high level restructuring is difficult and time-consuming.

Second and conversely, the transition from non-tayloristic to traditional work structures is relatively quick and unproblematic. Because tayloristic work forms involve authoritarian top-down work structures, their implementation may be easier than going from a traditional to non-tayloristic strategy as the former represents an organisational form which has been tested and the one with which managerial levels possess experience. In Brazil, where tayloristic work structures are more the norm than the exception, this is specially true.

Third, in general terms, wider organisational factors are the ones to which management paid less attention during the whole restructuring process. There are two explanations for this. On the one hand, linkage between organisational changes and productivity improvements are neither direct nor clear. The exception are organisational structure changes used as cost saving devices through mass dismissals. On the other hand, linkage between shopfloor organisational innovations and productive improvement are evident, so the higher restructuring is found at direct and indirect manufacturing indicators level.

9.4 TESTING GUIDELINES FOR ASSESSING HUMAN-CENTREDNESS

After differentiating HC firms from non-HC firms, both general guidelines presented in chapter 1 are tested in order to assess their utility. It is concluded that general guidelines can be used to support the restructuration process along HC orientation.

Testing General Design Guidelines

General design guidelines are tested by comparing the theoretical HC concept of chapter 1 with empirical data of HC oriented firms summarised in Exhibit 9.3.

'Organisation': The general guideline 'organisational design following object-orientation', was met by HC oriented firms. Key features can be detailed as follows.

- (i) Decentralised production units and 'firm within a firm' concept features were supported by the high degree of human-centredness achieved at 'manufacturing organisational structure' and 'organisational structure' indicators. That is, firms organised their operations 'by product' and used cellular layouts with, as far as possible, low interdependence levels among the cells. At firm structure level, the organisation was structured 'by customers' or 'by products'. Design activities for example, were performed by multifunctional and temporal teams.
- (ii) Delegation of responsibility to lower levels occurred to a medium extent. The high degree of human-centredness achieved in 'responsibility for output' and 'production follow-up' indicators together with a medium degree of human-centredness of 'work organisation set up' indicators support this argument.
- (iii) Planning results, rather than planning activities, were met as a high/medium degree of human centredness was achieved at 'production order issuing' and 'production order follow-up'

indicators.

(iv) An item that was not included in the theoretical framework, but one crucial to the effectiveness of HC organisational design is the existence of a coherent human resource policy (ie, career, wages, training policies) compatible with new organisational forms. The data here suggests a low level of congruence at present. However, management is aware of this shortcoming, but continue to practice tayloristic human resource policies due to particular contextual conditions such as weak trade unions and unemployment.

Concerning the item *technology*, the use of HC designed technology was not observed. Conventional technology was used in all cases. While this constrained, to some extent, the application of HC organisational principles, enough room still existed to reorganise operations.

The *socio-political dimension* of HC oriented firms had the following features, First, HC implementation did not threaten management control. As suggested above, the control of shopfloor operations has changed from direct to indirect: not at point of operation but through controlling 'results'. Second, the implementation of HC principles was not negotiated with workers. The paternalistic feature of Brazilian management led to a top down implementing made of HC principles. Neither trade unions nor workers were involved in the 'design' of HC principles. Third, politics 'of' and 'in' production were overshadowed by technical issues. It seemed that the political dimension of manufacturing organising and implementing work is still a taboo theme within management.

This finding point out to the need to examine the restructuring processes of firms from a broad perspective. That is, it seems to be that only the political-economy examination of contextual factors would properly explain the distribution of power relations inside the firms and this means the extent to which workers have real influence in production organisation issues (see Chapter 10).

The view advocated here is that the political negotiation of HC guidelines and wider political themes in manufacturing, are key issues that seem to be pre-requisite to the full implementation of HC principles. Without addressing these issues, the HC oriented firms risk being transformed into neo-tayloristic ones.

HC *work dimension* was not fully developed because of the above socio political issues. Then, in 'time structure' terms, workers experienced high restriction as the workgroup role, for example, did not involve time management tasks. 'Space of movement', was also limited by the

lack of highly skilled workers.

Concerning *social relations*, the research did not explicitly observed social relations. However, informality is a feature of Brazilian culture. While this supports quality social relationships at shopfloor level management attitudes and restricted means might prevent informal communication to a significant extent.

Restrictions on *responsibility and control flexibility* were low. Medium/high degrees of human-centredness found at responsibility for output, means of production control and production follow up indicators, all support this assertion.

The *qualification* factor was lacking, as the skill level at studied firms was not sufficient to allow for full rotation within workgroups.

Restrictions on *Stress control* can be qualified as medium level. The transfer of some planning and controlling activities from the PCP department to the shopfloor allowed some degree of worker stress control. Another source of minimising stress control was through the (informal or formal) set up of buffer stocks inside and between cells. As commented above, even in cases where a fully operational JIT system exists, some degree of worker stress control might exist as long as 'decoupler' buffers could be used to break the interdependency between cells.

Work group concepts, as applied in Brazil, can be qualified as non-HC oriented. That is, workgroups seem to adhere to neo-tayloristic or 'Japanese' forms. From this study, workgroups possess the following features.

First, expected results of work groups were concerned with gains in productivity and quality, but safety targets were not emphasised. Second, workgroups are task and group oriented. Responsibility for completing tasks is a matter for the whole group. Third, the role of buffers was to decouple from other work groups (inter-units or cells). However, despite that buffer existence, the fact that buffers effectively decoupled the work group was not enough to allow self-regulation of the group as the role of supervisors limited this option. Task interdependency between work units was, therefore, either tightly or loosely coupled, depending on the supervisor. Four, task interdependency inside the work unit was high. Five, tasks performed by the workgroups were: to a high extent, conversion; and to a low extent, regulation and boundary transaction. Six, job rotation was limited. Seven, the extent of decision-making of the work group was limited in terms of self-regulation and medium in terms of self-governance and independence (eg management of absences and holidays).

In general terms, it is possible to suggest that the studied HC oriented firms possess different profiles than the theoretical model presented in chapter 1. While a high/medium extent of human-centredness was achieved in some indicators (eg in some organisational and some work factors), other important issues, such as the socio-political shaping of manufacturing operations, were not addressed. Nevertheless, the Brazilian style of HC oriented firms clearly suggests that both a new management approach and a new firm market and organisational strategy are emerging.

9.5 GENERAL DESIGN ORIENTATION AND PRODUCTIVITY LEVELS

An important research question is whether or not the application of the HC model is superior to other organisational design orientations in productivity terms²³⁰. Our empirical evidence showed no clear productivity consequences. However, the data needs to be interpreted considering macro contextual conditions.

The domestic economic recession and high inflation rates were two key features of the Brazilian economy in the 1980s and early 1990s²³¹. The domestic economic recession meant

²³⁰ It should be noted that productivity levels are the result of intra and extra firm level factors. While firm level factors can be managed, extra firm level factors such as meso and macro economic conditions, go beyond the firm's range of action. Excepting machine acquisition, two main sources of productivity can be identified from the industrial engineering (IE) perspective.

First, productivity increases from improvements in methods of production. That is, as a result of the fewer manufacturing operations carried out to perform the same task, less time is spent on each manufacturing operation (less time in auxiliary operations such as transport, co-ordination), and productivity may be enhanced. This outcome stems from the improvements in the ways work is organised, at both the work station and between different sections/departments levels as well as from design improvements. Studies of time and motion, for example, are made using traditional Industrial engineering techniques to set up the 'one best way' of performing manufacturing operations. That is, unnecessary activities and movements are eliminated in order to maximise worker output. Improvements in the way work is organised between sections/departments, improvements in transport/transfer of raw materials, the auxiliary equipment availability, and flow-line balancing are the basic traditional techniques used to organise industrial work. Improvements in design activities constitute one of the most important sources for enhancing competitiveness (Whitney, 1989). Design activities not only select particular patterns to machine/assemble the product, but restrict also the alternatives to performing these productive operations. This reduces the number of choices regarding shop floor operations realisation.

The second way to increase productivity is through the increase pace/load of work to each worker. In other words, production personnel will perform a higher number of manufacturing operations per unit of time. The problem is determining the source of productivity. The extent to which productivity improvements resulted from better production methods and/or from enhanced pace/load of work needs to be found. Still, at firm level, there are other means to improve productivity and profits at shopfloor level. They are mass dismissals, use of financial markets and significant increases in prices. While the former increases productivity at shopfloor level, the latter increases profit rates and is not related to manufacturing activities.

²³¹ High inflation rates and the indexed feature of Brazilian economy are key factors that help to explain

lower economic activity and lower demand. This implies a lower utilisation of productive capacity. Personnel lay-off can be used to cover both a firm's personnel excess capacity, and to increase productivity by employees when lay-offs are higher than the required balance between machines, demand and available personnel. A heavier workload is assigned to remaining personnel. In the case of the Brazilian researched firms, it seems that they used personnel lay-off for these two purposes. It is important to remember that the economic downturn was accompanied by high unemployment rates which weakened trade union bargaining power. Therefore, management implemented these strategies with little worker opposition.

While productivity indexes used in the present research, do not include financial gains, they do include price increases and mass dismissal. The important point however, is that even with these considerations, it is very difficult to differentiate between sources of productivity improvements - mass dismissals, changes in production organisation and investment in capital equipment - occurred simultaneously and in different organisational levels. Therefore, even if work and organisational restructuring strategies are compared to productivity by employee levels, this does not mean that the productivity gains obtained were a direct result of the restructuring strategy applied.

It is within this context, that the productivity data (see Exhibit 9.8), needs to be interpreted. Productivity by employee levels and productivity by dollar invested in fixed capital is related to the restructuring strategy adopted. It is possible to observe that productivity by employee is higher (and positive) when compared with productivity by dollar invested in fixed capital (eg machinery). Possible reasons for that are (i) little capital investment occurred during 1987-92 due to the domestic economic recession; and (ii) because during the economic recession demand dropped considerably and the ratio of unused machinery in manufacturing facilities was high. All but one firm practised mass-dismissal as one means to re-equilibrate their manpower capacity with demand levels. Firms also restructured, to a greater or lesser extent and rethought their business strategies as well as their organisational structures. They introduced new work and organisational forms to cope with the recession in the domestic markets and newly targeted foreign markets.

why productive firms preferred to invest in financial markets rather than in the productive sector. The indexed feature of Brazilian economy, the lack of a minimal level of competition (in several cases) and a lack of government mechanisms to avoid exaggerated price increases, allows firms to re-adjust their prices beyond inflation levels. It is important to note that the Brazilian economic crisis was solely in the industrial sector(1980-1994). The financial sector have continued to grow even in the midst of economic recession due to the special financial arrangements maintained by the central government to finance the public deficit and foreign debt.

Restructuring strategy	Firm	Productivity by employee (%) 1987-1992	Productivity by capital investment 1987-1992 (%)
HC oriented	OSA	+ 40	- 2
	SIE	+23	- 39
	WAB	+23	- 5
Neo-taylorist type	VIL	n.a.	n.a.
	ML	+38	-19
	CLA	+27	- 5
	YAN	n.a.	n.a.
Non human-centred	EMB	+ 35	- 80
	WOR	+ 21	n.a.
	WEG	- 5.5	+64

n.a. Information not available

Exhibit 9.8 : General Design Orientations and Productivity Levels

Positive results of productivity by capital investment (eg machinery acquisition), can be attributed not only to intrinsic features of equipment bought but also to the way that equipment was used. Negative results of productivity by employees can be interpreted as the outcome of the lack of demand rather than negative work performance of personnel. Thus, from the available data no conclusive statement can be made regarding productivity and general design orientation adopted.

Nevertheless, it can be suggested, tentatively, that non-HC design orientations (ie taylorist or neo-taylorist) can be as competitive and viable as HC type strategies. Returning to Exhibit 9.8, it can be observed that most productive firms in each restructuring strategy group, are the ones in which internal fit was suggested. At 'osa' (a HC-oriented firm), for example, internal fit existed between components of the horizontal and vertical dimension. Osa, can be considered a 'greenfield' firm. In the early 1980s it changed owners. The new directors promoted total restructuring and newly appointed top management levels introduced a 'new' organisational structure and practices which were defined explicitly as 'anti-Japanese'. At 'osa', HC principles were implemented to a significant extent. In this case, it is possible to suggest that the high productivity by the employees was obtained from the combination of both mass dismissals and

the introduction of new work and organisational structures.

The same can be asserted regarding 'emb' (the non-HC type firm). At 'emb', clear tayloristic-like principles were applied to all indicators. In this case, it is possible to assert that employee productivity gains, came from the mass dismissals that occurred between 1990 and 1992. During that period 'emb' reduced personnel from around 12,000 staff to 6,000, while implementing insignificant organisational changes.

At 'ml', a neo-taylorist firm, tayloristic like work structures and organisational deployment occurred at some organisational levels and HC like work structures and organisational deployments were installed at other levels. In this case, positive results of productivity by employees can be credited to the fine tuned matching of differentiated strategies of both production and labour organisation applied at shopfloor and wider organisational levels²³². The 'ml' experience is used as an example to illustrate how the 'Japanese' approach is applied in Brazil.

Empirical data lead us to suggest that improved labour productivity levels were not only because of the use of modern industrial engineering techniques but also from the need of workers to preserve their jobs as tight labour market conditions existed by that time, resulting from domestic economic recession.

In light of these findings, can be suggested that new design orientations of production systems are not only influenced by technical and market related "needs", but also by the wider macro economic context in which the firms operate. In non-tight labour markets and moderate economic activity conditions, macro contextual factors (and specially industrial relations issues) seems to be fundamental to explain firm competitiveness. This may be the case in highly industrialised nations. However, in situation of tight labour markets accompanied by low economic growth, the balance of power favour the management. So industrial relations factors become less important as other factors acquire strategic importance to firm competitiveness. On the shopfloor, a key reason is that workers will be pressured to improve productivity in whatever work and job conditions. Therefore, the economic success of

²³²

As commented earlier, 'ml' applied tayloristic work structures at direct manufacturing indicators and only low levels of human-centred principles at indirect manufacturing indicators. In both cases tayloristic like labour organisation was applied.

A medium/high level of HC principles was applied at wider organisational indicators and horizontal cellularisation indicators. This supported effective functioning of the Japanese approach in this case, was the existence of match between labour organisation and organisational structures implemented at both shopfloor and firm wide level (top and middle managerial ranks).

(neo)taylorist firms might be based on low wages and coercive direct control conditions. The independent relationship found between general design orientation adopted and productivity levels opens new questions that go beyond the present study but deserve greater attention.

9.6 HCMS UNDER DIFFERENT PRODUCT/MARKET, DESIGN AND MANUFACTURING STRATEGIES

9.6.1 INTRODUCTION

After differentiating firms that follows HC principle from firms that do not, the present section examines whether firms' product and market position and its associated manufacturing and design strategy influence the degree of human centredness achieved. This is important because the HC literature (cf Sorge and Streeck, 1988) has stressed that HC restructuring is better suited to firms whose business strategy is oriented to quality/customised markets. However, a research gap exist regarding the application of HC principles in non quality/customised markets.

The argument developed here is that a firm's products and market strategy and its associated degree of congruence between manufacturing and design strategies, do not seem to be related to the achieved degree of human-centredness. This is shown through the examination of empirical data.

9.6.2 THEORETICAL NOTES

The starting point is Sorge and Streeck's (1988) arguments, that relate a firm's product and market strategies with product and labour markets. Sorge and Streeck point out that HC-type firms perform only in some types of industrial work and this is related to existing macro institutions. In order to test Sorge and Streeck's argument each type of industrial work is examined complementing it with two additional perspectives. First, design and manufacturing strategy is examined in order to relate this to a firm's business strategy. Second, organisational theory concepts are used in order to understand why different types of work are better suited to different types of industrial work and whether or not this is deterministic. This is important because it will allow us to establish whether or not a firm's product and market strategy together with its associated manufacturing and design strategies influence the degree of human centredness achieved.

Sorge and Streeck's (1988) institutional analysis, links product markets, work organisation and skill levels through batch size and economies of scope. Depending on the strategic choice made by management, which in turn, is constrained by macro institutional local conditions, firms establish a well defined range of batch size. This choice of what product(s) are to be manufactured and in which market segment they will perform, represents the business strategy

of the firm. That decision is shaped by factors external and internal to the firm such as local labour market, the availability of skilled workers and the trust level between management and workers. In short, firms choose to manufacture products along one of the following four general groups: (i) standardised products in low volume; (ii) standardised product in high volume; (iii) highly customised production in low volume; and (iv) mass customised products. Each case (see Exhibit 9.9) can be characterised as a specific production model that '... consist in a historically-institutional need of production comprising a web of production technologies, employment relations, methods of organising the intra-firm and inter-firm division of labour...' (Storper, 1991:105). Group one then, corresponds to the traditional taylorist model; group two to the fordist model; group three to the HC model and; group four, has different interpretations. Flexible specialisation (Piore and Sabel), 1984; Diversified Quality Production (DQP)²³³ (Streeck, 1992) and lean production (Womack et al, op cit)²³⁴.

Depending on the product profile and its associated batch size, the firm will be able to define its particular manufacturing competitive stance. That is, on the one hand it will define which are the key manufacturing competitive stances²³⁵ that make its customers buy the firm's products. On the other hand, based on comparisons with main competitors, firms may establish their actual competitive performance (Slack, 1991). After determining the key competitive stances firms adopt particular design and manufacturing strategies²³⁶. Both product market strategy signals the different design and manufacturing needs that firms with different products possess.

²³³ An additional comment is needed on the DQP model as it embraces many concepts of the HC model. Based on the German economy, Streeck (op cit) pointed out that nations trying to follow this strategy need to possess strong institutions to set up and organise adequate macro conditions for DQP. They include, (i) redundant capacities (eg skills at firm level and R & D at inter firm level); (ii) high trust; (iii) collective production of basic and applied research. As all these features require collective resources that individual firms cannot generate, the political intervention of institutional actors is important. In Streeck's words, "Institutions are the ones who generate, impose and enforce social obligations that rational individuals would not voluntarily and contractually take upon themselves" (p. 37).

²³⁴ It should be noted that these categories were defined more in industrial sociology terms than in quantitative terms of batch size, production scale and scope. Then, they overlap some aspects. At this point, it is suffice to say that the lean production approach can be located somewhere between quadrants 2 and 4; and DQP somewhere between quadrants 4 and 1. Flexible specialisation is the less defined in terms of product features and market targets.

²³⁵ Cost, quality, flexibility, fast throughput and reliable delivery are the 5 competitive stances (Slack, 1991).

²³⁶ Terry Hill (1994) differentiated competitive stances in order-winners and qualifiers. While the former is the one that 'win' a production order, the latter are important for the firm to be considered in the buying process. Then, a crucial step in developing a manufacturing strategy is the determination of how products win orders in the market place.

Design strategy must support the achievement of the business strategy. Design strategy is concerned with how design resources must be deployed to develop a product. It includes creating, defining and selecting a set of development projects; integrating and co-ordinating functional tasks, technical tasks, and organisational units involved in development activities over time; managing development efforts so they converge to achieve business purposes; and creating and improving the capabilities needed to make development a competitive advantage. Defined product/market strategy influences design strategy as it set the degree of complexity of design activities by defining the number of core products, number of derivations products and frequency of new product introduction (Clark and Wheelwright, 1993:89-96). In other words, the firm's design profile is influenced by the firm business strategy (ie product/market strategy) in two forms (Badham, 1991). First, the relative priority given by managers to the whole design process or to some specific parts of the design process, such as development of conceptual design (modelling or engineering analysis) or drafting activities²³⁷. Second, the relative importance given to the design activities as a whole in respect to manufacturing activities.

Manufacturing strategy can be defined as the deployment of resources as a means of achieving business objectives. On the one hand, it involves making choices about manufacturing processes, defining the role of inventories, and defining trade-offs. On the other hand, the manufacturing strategy must define the manufacturing infrastructure such as the mechanisms and procedures to control operations, work and organisational structures as well as support functions (Hill, 1985). Simultaneously, the firm's manufacturing strategy needs to be aligned with the firm's human resource policies, training practices, reward policies, work organisation and organisational structures. The existence of congruence between different organisational factors at firm level seems to be a crucial factor to achieve competitiveness at firm level (Skinner, 1985).²³⁸

²³⁷ Subjective factors such as shape, style and the relationship with other parts of the product, open up the number of variations that can lead towards an 'underconstrained design situation' (Medland, 1986) which stimulates major changes in the product concept. In contrast, when objective factors are easy to quantify, the shaping of the design problem is centered around analytical techniques which are directed towards the reduction in the number of feasible alternatives. Physical properties, operating conditions and cost constraints are examples of these objective factors. In this case 'overconstrained' designs tend to become a compromise between well defined parameters. A capital equipment industry represents this second kind of design profile well. However, most design environments contain a mixture of both these parameters with a bias, depending upon the enterprise activities (Medland, op cit, p. 109-10) While in the latter case CAD used for modelling or engineering analysis (eg the use of FEA techniques to test out materials stress) is the more adequate, CAD utilisation for drafting activities fits better with enterprise competitive commitments in the former cases.

²³⁸ It should be noted that this claim is being challenged (cf, Cusumano & Nobeoka, 1992; Vickery, Droge & Markland, 1993) as no direct linkages were found between business performance and business strategy congruent with organisational structures.

If the market target choice is price driven, quality, variety and variability aspects are not the crucial factors, but output volume and low cost. The fordist type of work organisation fits well in this case. If the market chosen by management is quality driven, the variety and variability²³⁹ of demand are crucial elements. In this case, non tayloristic work and organisational structures which can discover different solutions to constantly changing technical and organisational problems are adequate (Child, 1987b).

This means that, a particular combination of quality, batch size, variety and variability requirements needed by the industrial organisation, influences the type of technology used (in terms of scale, degree of automation and integration), the way operations are planned and controlled as well as organisational factors such as work organisation, organisational structure and personnel policies.

What is important in examining products and markets target and its associated design and manufacturing strategies, is the way the firm matches product profile and existing the firm's internal capabilities in design and manufacturing terms (Leonard-Barton, 1991; Cusumano and Nobeoka, 1992). Hayes and Wheelwright's (1984) product-process matrix, for example, points out direct linkages between product profile and its process technology. On the one hand, a narrow product range calls for higher production scale. This in turns, is suited to highly automated/integrated process technology (eg an oil refinery). On the other hand, a wide range of products need to be manufactured in small or medium sized batches. This product profile calls for generalist equipment.

The organisational structure at each quadrant of Sorge and Streeck's scheme can be configured in different ways because its components, called organisational design parameters, are of a configurational nature. That is, each one can be arranged in a wide range of forms.

Because of new social, institutional and market conditions, organisational structure²⁴⁰, work structure²⁴¹ and associated task structures²⁴², are changing in some organisations. Depending

²³⁹ Child (1987b) stresses the importance of variety and variability for organisational design. Variety refers to the amount of different products manufactured. Variability refers to 'the degree of irregularity in the overall pattern of change' (p.113). A high variety and low variability situation implies in a production process in which changes can be forecast well in advance. This relates only to a larger amount of data processing for production activities. In this case the ability to perform quick changes from one batch to another is important. For Child, in this case, decentralised work structure favours good performance.

²⁴⁰ Organisational Structure involves the general framework used to plan, divide, co-ordinate and control key organisational elements. These are: the number of hierarchical levels, grouping of activities, allocation of responsibilities, design of information systems, delegation of authority and the reward system (Child, 1984). The final form of the organisational structure, therefore, can be well represented by a production model.

on existing levels and combinations of uncertainty²⁴³ and interdependence²⁴⁴, a task might be complex²⁴⁵ in a higher or lesser degree. Depending on task complexity degree, different form

241 Work structure embraces the interactive deployment of people and machines in the workplace. The role of work structure is the co-ordination of interrelated workstations in which each individual job possesses a particular load of work, level of uncertainty, complexity and discretion over its immediate reality of work in order to accomplish the assigned task. The personnel involved need the corresponding level of skills, responsibility and power to perform the task assigned. Thus, the setting of work structure has direct implications for the quality of individual tasks as well as for the performance of the production system as a whole.

According to Child (op cit), work structure involves the (production) workflow, levels of buffer stocks between work units, type of supervision, reward systems, the way different tasks performed are planned, co-ordinated and controlled. Work structure analysis, can be either individual-oriented or group-oriented. In the present study, work structure is bounded by a specific work unit. For example, a work unit may be defined by a section where a specific part or component is machined. In this way, the work unit is the section and the work structure might be organised, for example, either along tayloristic or socio-technical lines.

Work structure, therefore, seems to be the materialisation of: (i) environmental contingencies such as market pressures and management/user relations at firm level; (ii) technological constraints that the 'system architecture' of the MES brings (see chapter 4); and (iii) firm level negotiation (between management and technology) about the definition of the operating activities. In addition to organisational factors, other political, psychological, cultural and ideological factors influence organisational structure. This is why organisational writers(cf Mohr, 1971; Hickson, Pugh and Pheysey, 1969) are unanimous in negating the cause-effect relationship between organisational structure and technology.

242 Tasks structure, is the core component of work structure. Tasks are activities carried out to transform materials into output, transport materials/outputs and planning, and/or co-ordinating activities directly related to the transformation process. Task uncertainty, task interdependence and environmental turbulence, are the principal variables that the literature (cf Slocum and Sims, 1980; Cummings and Blumberg, 1987; Susman and Chase, 1986) uses to analyse work organisation modes in high technology environments. The set up of the work structure is an interactive two-way process. It is not task uncertainty and interdependence that determines the final form of work structure, nor work structure which automatically defines task uncertainty and interdependence levels. The setting up of work structure is a negotiation process in which different factors and social actors shape the final form. They are, in part, cause and, in part, effect of work structure. In this sense, task structure can be approached as "the incorporation of a social choice into a concrete, operating structure" (Butera & Thurman, 1984:161).

243 Task uncertainty is blamed for changing work and organisational structures under volatile and changing market conditions (Gerwin, 1988). It possesses two main dimensions, as argued by Slocum and Sims (1980:198-200). The first is the lack of knowledge about how to perform the task. This dimension may or may not be linked with the technology used to perform the task. In the first case, it refers to a lack of knowledge about machine operation. In the second case, the uncertainty level is a function of the external environment, such as market pressures. The work of a construction worker or of a doctor are good examples to illustrate this case.

The second dimension is related to the level of unpredictability regarding when a task should be performed. The work of an emergency worker or telephone operator are examples of this case. The amount of information and decision-making necessary to execute the task is also influenced, to a great extent, by the control mechanism used during task execution (Cummings and Blumberg, op cit). That is, if personnel process limited information and take few decisions, it means that the work being performed is routine. Therefore, external control mechanisms such as supervision or use of production standards are adequate. Conversely, if the amount of information needed to be processed is high and the person takes a significant decision-making role, it implies dynamic and varied work. In this case, self-control of employees is the most suitable organisational mechanism.

of work organisation will be suitable for specific situations. Self-regulating work groups, for example, are suitable for situations of high task interdependence and uncertainty (Cummings and Worley, 1993). In turn, depending on the degree of task uncertainty and interdependency, firms' organisational structures possess different degrees of work structure integration and decentralisation. This is the reason why HC-oriented firm should possess high levels of organisational integration and decentralisation in order to cope with uncertain and interdependent tasks²⁴⁶.

Susman and Chase, (1986) argued that in advanced manufacturing environments, the levels of uncertainty and interdependence are high. This means that tasks and technology are uncertain and high levels of skills are necessary to cope with the complex tasks generated. Interdependence means that different functions and tasks will tend to be integrated.

²⁴⁴ Task interdependence takes into consideration the different relationship that one task can possess with another. The degree of interdependence is important because it influences communication patterns, levels of co-operation required, control mechanisms and formation of groups. Interdependent tasks can be pooled, sequential or reciprocal (Thompson, 1967:54). Pooled interdependence is when each part (work unit for example) yields almost independently, a contribution to the final product. Sequential is the case whereby one task must be finished before other one begins. Reciprocal interdependence is where the output of one becomes the input of another and vice versa (Slocum and Sims, op cit). The degree of task interdependence can vary from high to low. In the low level extreme, one task is not related to another. That is, they are almost independent. In the other extreme, all tasks are intrinsically related and the termination of the parts is essential for the successful performance of the whole task.

Task interdependence, is partly a function of the architecture of the technological system and partly a function of the physical features of the output. This is often true of advanced manufacturing environments, for example, in which technology is complex and interconnected. The 'architecture' of the system is usually designed to co-ordinate separate operations to accomplish a common final product. In this case, task interdependence is directly related to technological interdependence. Some authors prefer the term technological interdependence rather than task interdependence. Physical features of the output, on the other hand, also influence the degree of task interdependence.

²⁴⁵ *Task complexity* is related to the information load and information diversity necessary to perform a task (Campbell, 1988). There are four features that increase task complexity: (i) the presence of multiple potential paths to achieve the desired goal; (ii) the presence of multiple desired outcomes to be attained; (iii) the presence of conflicting interdependence among paths to achieve multiple outcomes; and (iv) presence of uncertain links among paths and outcomes. All factors contribute to an increase in the degree of task complexity. Tasks which do not possess any of the above four features can be labelled as simple tasks. Conversely, tasks that possess any of those complexity sources can be considered as more or less complex tasks.

²⁴⁶ Technological factors seem to play a role not because of any deterministic feature of the technology, but because the workflow - one of the elements of technology - is related to task structure that which, in turn, is a basic element of work structure.

The above suggests that the way work structure in high technology environments is set-up, is crucial for its successful utilisation in both social and economic terms²⁴⁷. Higher task structure uncertainty and interdependency calls for both decentralised and integrated work structures.

Exhibit 9.9 shows Sorge and Streeck's matrix, in which each of the quadrants represents a limited number of coherent logic of production. That is, different ways of designing, manufacturing and relating them to the existing competitive stance, skills, and resources. In turn, each logic of production is not only a function of market and technological factors but also of socio-organisational factors or conventions²⁴⁸.

Depending on the market target chosen by management, the enterprise will be in a particular competitive stance and will need to develop particular critical competencies for both design and manufacturing functions (PA Consulting Group, 1989). Therefore, both design and manufacturing spheres must be appropriately organised to achieve a critical competitive stance. Each one of the business positions (quadrants in Exhibit 9.9) fits better with a particular response in both design and manufacture spheres (Brooks, 1990). It should be noted that organisational arrangements mentioned below are not deterministic. They outline only Sorge and Streeck's generalisation from the German industry²⁴⁹.

Cell 1 is the case in which standardised products are manufactured in small batches. Fashion products and jobbing work are representative of this quadrant. Task complexity is low. However, task uncertainty is high because it is great difficult to predict which standard

²⁴⁷ McLoughlin (1990) for example, stressed this point in the conclusion of his research carried out in four British industrial firms that use extensively CAD technology.

²⁴⁸ Current conventions of quality and flexibility further explain the way the industrial world has been divided. "Conventions are practices, routines, agreements, and their associated informal or institutional forms which bind acts together through mutual expectations ... A convention for the evaluation of the quality of a product establishes the boundaries of competition in a world by defining the relative economic values of qualitatively distinct factors of production ... Conventions of flexibility define practices of resource deployment, in the fact of different kinds of market fluctuations"(Salais & Storper, 1989:171-180).

²⁴⁹ Before explaining theoretical features at each quadrant of Sorge and Streeck's scheme, two points should be noted. Firstly, no mechanistic assertions can be drawn from this model. The model serves only to show the main patterns of work structure under different strategies. There are a constellation of possible contingencies that affect the final form of work structure. Hence, the model shows only ideal types and stresses the extreme situations in order to highlight the wide range of possible work structures in a manufacturing system.

Secondly, the elements that compose the work structure, in different work units, such as task interdependency and uncertainty, are configurational. That is, while the architecture of the technological system may limit choices about the set up of the production work flow, it is management that usually defines the way tasks are grouped, divided and co-ordinated among different work units. After that, during the implementation process, tasks are reconfigured by technology users and implementators.

		PRODUCT TYPE	
		STANDARDIZED	CUSTOMISED
BATCH SIZE	SMALL	1	3
	LARGE	2	4

Source: Sorge & Streeck, op cit

EXHIBIT 9.9: Product and Market matrix

product will be demanded next. Task interdependence is low as often process technology is small scale, labour intensive and non-integrated. Firms' competitive stances are price, delivery/availability and product performance, in this order. Primary manufacturing competence concentrates upon achieving a reactive, short lead time response. In order to meet this, rapid design capabilities (emphasis in drafting), flexible automation and reactive scheduling functions should be focused. (PA Consulting Group, op cit). Theoretically, routine work²⁵⁰ exists and co-ordination is achieved through standardisation/planning (Thompson, 1967); rigid and centralised control (Perrow, 1971); and functionally arranged organisational structure (Donaldson, 1985). In short, work units deployed under divisionalised, bureaucratic structures (Pugh and Hickson, 1976; Mintzberg, 1979) are typical forms of this cell. In summary, taylorist practices are the norm.

Cell 2 denotes the production of standardised products in large batches. Commodities and volume producers are typical industries in this quadrant. The firms' competitive stances are price and delivery/availability, in this order. The design function is minimised compared with the manufacturing one. In manufacturing terms, the goal is to obtain minimum production costs through the use of elastic labour capacity. To obtain this, capacity planning, continuous production and delivery logistics and maintenance functions are emphasised (PA Consulting Group, op cit).

Theoretically, in this situation the level of task interdependency is high because technology is usually highly integrated. Task uncertainty is low as output is standardised. Like in quadrant 1, the typical organisational structure associated with it possesses a high centralisation and division of labour. Theoretically, this type of production fits well with fordist type forms of work and organisational structures. That is, work is vertically divided, both semi-skilled and unskilled labour is used and tight control mechanisms exist. The use of systematic mechanisms of control is common practice in these cases. This embraces the presence of minutely planned instructions on how the work is to be executed and the standards to be attained, including output volume and built-in monitoring devices to control performance.

Firms in cell 3 manufacture customised products in small batches such as the capital equipment industry. The firms' competitive stances are, in this order, product performance and delivery/availability. In design terms, this product calls for the existence of sophisticated product development capacity. In manufacturing terms, production needs to be versatile and centralised planning activities are crucial (PA Consulting Group, op cit). This type of product calls for HC type work and organisational structures. Then, in AMT environments, task

²⁵⁰ High horizontal and vertical division of labour, pacing rules and detailed work planning are some key features of routine work.

interdependency and uncertainty is high. That is, complex tasks need to be performed to achieve specific goals. However specific means or methods do not exist to achieve these goals. A team established to develop a new product is a typical example of this case since their interrelationship are temporary, they possess interdisciplinary specialities and their work is centred towards the solution of particular problems. The internal structure of the work unit should possess enough flexibility to meet the requirements of the tasks using the following means: mutual adjustment (Thompson, op cit) co-ordination mechanisms; the control mechanism should be flexible/decentralised (Perrow, op cit) or developmental; and organisational structure should be composed of cross departmental teams and/or matrix structures (Donaldson, op cit). In short, work units deployed under adhocratic (Mintzberg, op cit) and organic (Hage, 1977; Burns and Stalker, 1968) forms are typical of this cell. This situation from the organisational perspective, is a good representation of an ideal type of HC manufacturing system.

This implies an existence of a general goal to be achieved in a specific period and with a set of norms and expectations regarding the general nature of behaviour and interaction among employees. This co-ordination of an organisational mechanism allows team members to absorb environmental uncertainties by given them the space to cope with them freely. In CAD/CAM environments, the work performed by a design team or FEA analyst group is representative. The ideal work organisation follows integrated/decentralised features.

This type of high decentralised/integrated work structure, in which different work units possess a relative 'autonomy' while being responsive to the whole system's needs, can be better described using the loosely coupling concept (Weick, 1976; Orton and Weick, op cit). This concept suggests that there are elements within a system that are linked and preserve some degree of determinacy (coupled) and these elements are subject to spontaneous changes and preserve some degree of indeterminacy (loosely). The result is an ambiguous/dialectic system in whose elements are, at once, interdependent and autonomous, open and closed as well as static and dynamic. Therefore a loosely coupled system is one in which,

elements are responsive, but retain evidence of separateness and identity... elements affect each other suddenly (rather than continuously), occasionally (rather than constantly), negligibly (rather than significant), indirectly (rather than directly), and eventually (rather than immediately) (p.203-4).

It may be noted, that the concept of loose coupling, with its recognition of numerous configurational dimensions, is useful for explaining the way the different dimensions of work structures are configured. Additionally, technology and organisation considered as loosely coupled systems help to explain the absence of simplistic cause-effect relationships.

The active intervention of management, technology vendors and technology users through negotiation processes is promoted at both the design and implementation stage. As far as possible, the technology used must be HC designed. Control activities are transferred from the office to the shopfloor. This means that labour must be highly skilled, not only to cope with requirements of the new technology but also to perform some micro planning and controlling activities. The existence of strong training policies, career paths and reward systems that recognise workers skills, responsibilities and performance achievements, are additional organisational elements that support this type of production.

Firms in cell 4 manufacture customised products in high volume. In this case competitive stances are, in decreasing order, delivery availability, product performance and price. The existence of a wide product choice from minimum component variety is the primary manufacturing competence to be developed. Adopting modular design is suitable to this situation (PA consulting Group, 1989).

Task complexity is high in theoretical terms. Task uncertainty however is not so high as in cell 3, as core products (or platforms) are stable. Task interdependence is high as large batches call for capital intensive and integrated technology.

Despite being volume producers, firms in this quadrant have a high degree of customisation (obtained from few platforms). This calls for flexible work practices in terms of both personnel and machinery deployment. Crucial production management activities are related to the design of the operation such as planning capacity, logistics and maintenance. Thus, despite the use of centralised planning and control of operations as well as functionally arranged organisational structure, low horizontal division of labour and use of self-regulated work groups is possible to be applied at work unit level.

9.6.3 THE EMPIRICAL EVIDENCE

After explaining the meaning of each quadrant in Sorge and Streeck's scheme, a comparison needs to be made between the empirical data and Sorge and Streeck's model. Based on the studied firms' design and manufacturing strategies and their product-market features²⁵¹ (see

²⁵¹ Manufacturing strategy is here represented by the firms competitive stance defined as 'order-winners' and by the firm's manufacturing response. Three basic design strategies were sharply differentiated. First, firms performing minor improvements in foreign design; second, firms performing major improvements in foreign design; and third, firms which have their own design capability. In the first case, design activities were marginal; in the second case, firms have some design capacity but it was limited; and in the third case firms possessed a well established design infra-structure. Using this data, follows a brief examination of the firms' design and manufacturing strategy. Theoretical competitive stance refers to the business strategy that firms should theoretically follow. Perceived competitive stance, refers to the business strategy that firms are following, as explicated by managers during interviews.

At 'yan', the tractor manufacturer, theoretical and perceived competitive stances are quite congruent. That is, both point to price and quality as being crucial for customers. Conversely, the firm's design strategy seems to be inadequate. Two reasons are given for this. First, the firm adopted the 'major improvements in foreign design' strategy. That is, product design is brought from overseas and extensively modified to be (i) adapted to local conditions of operation; and (ii) adopted to local conditions of production. Despite the need to possess a large design capability, the firm did not possess CAD technology and the design department is under-staffed. This design strategy would have been sufficient a decade ago when quality standardised products performed well. However, current market conditions call not only for price and quality but also for a variety of models. Second, the design age of existing products, limits to a significant extent the required modular feature of design to easily increase the product variety. To be competitive Yan needs to set up design strategies that allow the firm to move from cell 1 position towards cell 3.

When Yan's manufacturing strategy is considered, the firm's perceived strategy does not seem to be congruent with its theoretical strategy. In other words, the firm's emphasis on production planning, logistics and control of production, contributes little to achieving flexible manufacturing in terms of volume and variety. However, the full implementation of internal JIT with Kanban, does contribute to the achievement of range flexibility. In short, means and methods used in both design and manufacturing spheres seem to be incompatible with the firm's theoretical and perceived strategies.

At 'wab', the commercial brake vehicle producer, theoretical competitive stances are apparently divergent from perceived competitive stances. However, because it is an automobile part producer, its competitive stances emphasises quality and delivery flexibility. Price is not regarded as a first competitive stance because it is agreed upon before hand with key customers (eg automobile industries). What justifies its inclusion in cell 1 is: (i) the small size of batches (80 % of production is in batches between 11-100 parts); and (ii) 80 % of production is standardised. Wab's design strategy followed a 'minor improvement to foreign design' approach. That is, because it is a TNC, product design is made overseas and subsequently minor changes for adaptation to local conditions are made. In this way, the non-utilization of CAD resources hinders, to some extent, the achievement of design modularity. However, this is widely compensated by the great emphasis that existed in detail design. Concerning 'wab's' manufacturing strategies, both theoretical and perceived strategies seem to be congruent. That is, the achievement of manufacturing (range) flexibility is considered important as a high

variety of standardised products are produced (6 product lines with 80 models). In summary, wab's design and manufacturing strategies seem to converge towards the achievement of the general business strategy. However, the building of a design group with CAD equipment, may contribute substantially to obtain rapid product customisation. This implies a move towards cell 3, where higher quality and variety are needed but premium prices are also obtained.

Weg's business strategy seems to be lacking. That is, theoretical competitive stances are not congruent with perceived competitive stances. The reason may be that their products (AC/DC electrical motors) are a quasi-commodity. With this type of product range, the theoretical competitive stances are price and performance, while perceived competitive stances are quality, delivery flexibility and price. An alternative explanation for weg's business strategy, is that, as 'weg' was looking to increase its overseas market share, they were attempting to improve quality and delivery times as the price factor was already 'controlled'. When its design strategy was considered, both the theoretical and perceived design strategies seemed to match to a significant extent. That is, the firm's design resources were oriented towards the achievement of a modular design. This feature supports further customisation of products. The latter implies a move from cell 1 to cell 3. In reality, weg's position at Exhibit 4.3 is justified because 35 % of their production is customised.

At 'wor', the pump manufacturer, theoretical business strategy matched perceived business strategy to a significant extent. Their perceived design strategy conversely, seemed to be lacking when compared to their theoretical design strategy. First, their design capability is limited to the adoption of foreign generated designs. It should be noted however, that this was an ad-hoc strategy, as the MNC possesses strong design capability overseas. Therefore, while this strategy may suit the current firm strategy, the non existence of CAD capability hinders their capacity to rapidly adapt foreign designs. Wor's manufacturing strategy seemed to be lacking in terms of their second manufacturing priority, that is, the non targeting of 'versatile production'. Instead the emphasis is on 'continuous production'. This is an important shortcoming as 90 % of the firm's production is customised. In short, it seems to be that while wor's general business strategy is adequate, their design strategy and manufacturing resources were weakly organised in such a way to support the business strategy.

At 'vil', the lift manufacturer, theoretical and perceived competitive stances seemed to match. The features of their products, very similar basic engineering and highly customised finished parts, makes their design strategy adequate. That is, they possess considerable design capability and emphasise both detail and basic engineering as well as pre-standardisation of parts. Their manufacturing strategy seemed to be inappropriate as their second theoretical manufacturing competitive stance, versatile production, is not explicitly targeted. Therefore, in general terms, it is possible to suggest that, while the firm's design strategy supports the achievement of business strategy to a high degree, its manufacturing strategy does it to a lower extent.

At 'cla', the automotive power shift producer, theoretical and perceived design strategy were congruent. However, because CAD capabilities were used more for drafting than for modelling and simulation (CAE) activities, their design strategy seemed lacking. Regarding manufacturing strategy, the high emphasis on logistics and low stress in acquiring 'versatile production', seemed to hinder the firm's manufacturing strategy to support its business strategy. Versatile production is a key factor because 100 % of cla's products are customised.

At 'sie', the electric automotive part manufacturer, the theoretical and the perceived competitive stances were congruent. Perceived design strategy that emphasised detail design matched the theoretical design strategy. Their manufacturing strategy seemed congruent, as well. In general terms, the deployment of resources in both design and manufacturing, seemed to be congruent with the firm's business strategy.

At 'osa', the automobile plastic and rubber parts producer, both business and design strategies are highly congruent as their theoretical and perceived strategies match. Their manufacturing strategy nevertheless, was lacking as 'versatile production' seemed to be not a high priority (perceived manufacturing strategy). The achievement of short lead time calls for more versatile production than for strong production planning.

At 'ml', the engine parts producer, the business and design strategies seemed congruent. That is, theoretical and perceived elements matched to a significant extent in these two cases. Regarding manufacturing strategy, their perceived strategy seemed adequate in the medium term, as little emphasis was put on versatile production. In overall business, however, 'ml's' design and manufacturing strategies seemed congruent.

Exhibit 9.10), firms are located in Sorge and Streeck's scheme (see Exhibit 9.11). This Exhibit suggests that, according to Sorge and Streeck's theory, firms classified in cell 1 (yan, wab and weg) should be organised following the Tayloristic model. In a similar way, because the remaining firms were classified inside cells 3 and 4 (customised products area), theoretically they should be organised following HC orientations. Nevertheless, as the examination of studied firms shows, only 'wab', 'sie' and 'osa' were classified as HC-oriented. This partially challenges Sorge and Streeck's theory, as 'wab' was considered a HC-oriented firm, but still performs in standardised markets.

9.6.4 DISCUSSION

Examining business, design and manufacturing strategies of HC oriented firms (osa, wab and sie), we can observe that HC principles were systematically adopted in firms having different business strategies (ie, different product profile and market targets), together with its associated batch size and different design strategies. Convergence was found in manufacturing strategy terms only. All HC oriented firms of our cases have as perceived manufacturing competitive stances, quality and delivery flexibility.

Osa for example, clearly follows a 'differentiated mass-production' business strategy. Batch size is large (28 % of output is produced in 501-200 units and 46 % of output produced in batches of more than 2000 units), and it possesses its 'own design capability'. *Osa's* order-winning competitive stance is quality.

However, *wab* follows a customised made-to-order' business strategy. Batch size is small (80 % of output is produced in batches of 11-100 units) and follows a design strategy of 'minor improvements in foreign design'. *Wab's* order-winning competitive stance is delivery flexibility²⁵².

The above might lead us to suggest that HC principles are feasible to be implemented independent of the business, design and manufacturing strategy followed by firms. It needs to be recognised, however, that as no firm of the sample fitted in the Fordist region of Sorge and Streeck's scheme (quadrant 2), nothing can be concluded regarding this quadrant. This finding is important as it tentatively indicates that the HC model can be applied in firms producing in small batches quasi standard products and manufacturing environments having a low intensity of high technology.

²⁵² 'Sie' features are similar to those of 'osa'.

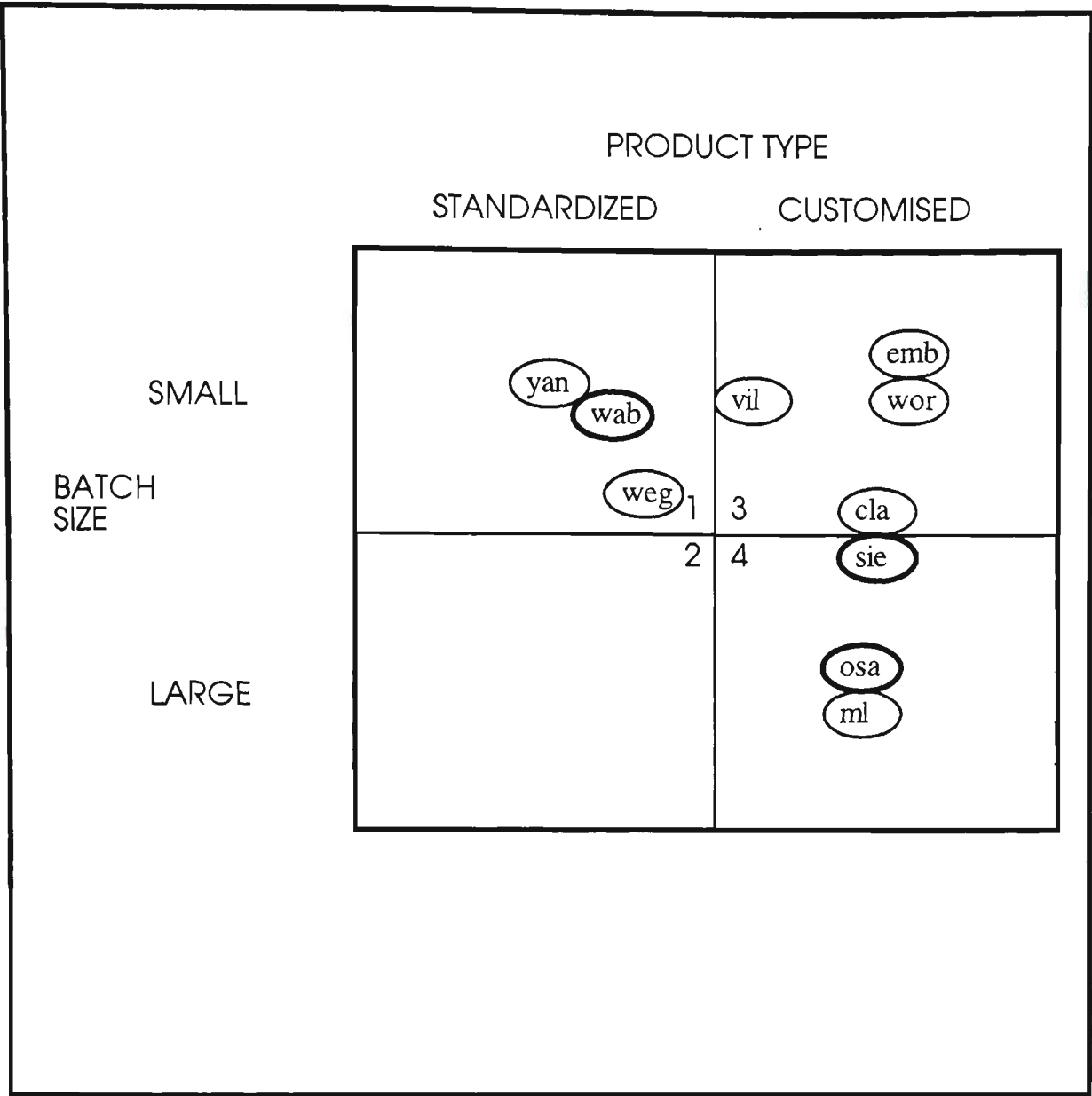
Design strategy	Firm	CAD usage	Manufacturing response ^a	Competitive stance	Product-market features
I. Minor improvements to foreign design	sie	no CAD	-effective logistics -quick reorganisa. manufacturing activities	-delivery flexibility -quality -price	'Differentiated mass-production': -complexity: low/med -scale: large -scope: med./high
	wab	no CAD	-quick reorganisat. manufacturing activities -effective logistics -reliable eng. DB ^c	-quality -delivery flexibility	'Customised made-to order': -complexity: high -scale: med. -scope: med.
II. Major improvement foreign design	Yan:	no CAD	-Strong PP -effective logistics -central PC ^b	-quality -output availability	'Standardised dedicated': -complexity: high -scale: small/med. -scope: low
	wor:	no CAD	-strong PP -continue production -central PC	-quality -output availability	'Customised made-to order': -complexity: high -scale: small -scope: high
III. Own Design Capability	osa	CAD for drafting	-strong PP -effective logistics -quick reorganisat. manufacturing activities	-quality -delivery flexibility -price	'Differentiated mass-production': -complexity: medium -scale: large -scope: high
	ml	CAD for modelling parameters. CN program	-reliable eng. DB -strong PP -effective logistics	-quality -delivery flexibility -price	'Differentiated mass-production': -complexity: high -scale: large -scope: small
	cla	CAD for drafting	-effective logistics -reliable eng. DB -quick reorganisat. manufacturing activities	n. a.	'Customised made-to order': -complexity: high -scale: med. -scope: small
	weg	CAD for modelling parameters.	n.a.	-quality -delivery flexibility -price	'Standardised dedicated': -complexity: high -scale: med. -scope: med.
	vil	CAD for parameters. drafting	-strong PP -effective logistics	-quality -delivery flexibility	'Customised made-to order': -complexity: high -scale: med -scope: high
	emb	CAD for modelling CN program drafting	-effective logistics -reliable eng. DB -quick reorganisat. manufacturing activities	-quality -delivery flexibility	'Customised made-to order': -complexity: high -scale: small -scope: small

EXHIBIT 9.10: Product - Market design profiles strategies

^a Strong Production Planning activities;

^c Reliable engineering Data Base for manufacturing operations

^b Emphasises central Production Planning activities



○ Human-centred oriented firm

EXHIBIT 9.11: Product and Market Strategy: Empirical Evidence

The above argument can be extended to examine firms that sharply followed tayloristic strategies ('emb', 'weg' and 'wor'). Even though 'emb' and 'wor' produce highly customised output on a small scale (and theoretically can be located in the HC type area), they clearly applied taylorist type principles. All this might suggest that the type of industrial restructuring (towards HC or Taylorist models, for example) seems to be little related to business, design and manufacturing strategies pursued by firms. This also implies that firms decide on adopting one restructuring model or another, and in this process organisational theory arguments play a small role.

This has crucial implications for research as it suggests that product profile, market target and design and manufacturing strategies are little related to the type of production model adopted. Additionally, while organisational theory literature recognises that organisational structure is closely linked to work structure and task structure, type of tasks performed by firms seems to be under-estimated in the decision process to chose one or another type of production model. If this is so, reasons need to be searched elsewhere such as the role of institutions, norms and values of the nation (ie, labour markets, general industrial relations system,)

Of course, as our examination is case study based, more research is needed to throw more light on this issue. In terms of research on HC models, these findings are positive as they suggest the feasibility of HC firms in semi-peripheral nations like Brazil challenge, the view that HC type firms can only develop in nations with strong institutions.

CHAPTER 10

CONCLUSIONS

10.1 INTRODUCTION

The exploration of the feasibility of applying the HC model in a semi-peripheral nation like Brazil and the examination of conditions that shape the HC-oriented firms, are the two aims of this study. This entails inquiring into the contextual conditions that support or hinder the adaptation of the HC model to Brazil and unravelling the key technical and organisational features of an adapted HC model in Brazil.

In order to operate the empirical component of this study, the HC concept was deployed in terms of 2 dimensions: (i) a horizontal dimension, that assessed the extent to which cellular layout were applied; and (ii) a vertical dimension, that examined the 'depth' of HC principles both at shopfloor and firm wide level. Finally, relationships between HC 'oriented' firms and key product and market features were analysed, in order to look at particular features that may influence the Brazilian profile of human-centredness.

Before outlining the key findings of this study, it should be noted that few studies about the development and introduction of HC manufacturing systems have elaborated a comprehensive model of HC manufacturing systems, that systematically attempts to operate HC features in terms of the varied influences that shape a manufacturing system. This thesis also has attempted to address this by elaborating the multi-faceted relation between productive activity and regional and national social, economic and political conditions. Further research is, however, required in order to define whether or not a clearly identifiable pattern of Brazilian development can be discerned as data was drawn from selective case studies. In what follows below key points are discussed in order to examine how both firm and contextual level factors converged to shape HC oriented firms.

10.2 TYPOLOGY OF BRAZILIAN FIRMS

In order to systematise the diversity of production systems found, a typology was made distinguishing between HC-oriented, neo-taylorist and tayloristic type firms. The key factors influencing the production organisation profile of firms are: (i) the wider industrial relations context and its associated labour market; and (ii) production scope (as a necessary but not sufficient condition). Sections 10.3 to 10.5 develops the latter and section 10.6 explains the former argument. This type of explanation converges with the arguments outlined in Chapter 3 regarding the need to use a broad view to explain the functioning of production systems. Those arguments stressed the importance of considering the macro contextual factors to explain firm level developments. Therefore, arguments at the level of the firm were centred around the configuration/processual perspective developed in Chapter 4. As expected, firm level insights were not sufficient for satisfactorily account for all developments that the application of HC principles implies. Firm level arguments therefore, based on the empirical component of this research, were supplemented by wider contextual grounded arguments developed in Chapters 3 and 5 in order to attempt an approximation of the reality.

10.3 VARIETY OF CONFIGURATIONS WITHIN HC-ORIENTED FIRMS

Most studied firms applied elements of HC systems, but did so partially and to different degrees. A close examination of researched firms pointed out that firms that do apply HC principles do not easily fall into the HC versus non-HC categories. Because the HC concept is multidimensional, firms adopted, to different extents and at different organisational levels, HC concepts. As a result, many firms are in the in-between area. Three sets of arguments explain the existence of a variety of HC configurations. Firstly, the implementation of HC principles can occur independently of market targets, product profile, the type of manufacturing processes involved and batch size.

Secondly, the processual/configurational model was useful in helping to explain the large diversity of organisational configurations found. The case studies clearly showed that both the organisational component and its individual factors (ie work structure, career paths, training policies) are of a configurational nature. That is, they were deployed in different forms.

Additionally, because the design stage is totally independent of the implementation stage, the technology users' role increased as they continually influenced designed organisational changes in order to fit their personal needs and local conditions of operation. In the present study, it has been suggested that, even in cases where users had a low profile during the

design stage, they nevertheless played an important role at the implementation and post-implementation stages. Technology users, for example, influence the way work is performed and co-ordinated with other work units. This is especially true in the formation of buffer stocks, which existed 'informally' in all firms and were worker 'controlled'.

Thirdly, local/regional conditions in which the firm is inserted seems to play an important role for understanding not only the variety of HC configurations but also to explain a variety of design orientations. The last two points are discussed in sections 10.6 and 10.7.

10.4 COMMON ELEMENTS OF HC-ORIENTED FIRMS

Those firms that did apply HC concepts systematically also varied in the degree to which they did so in different areas. The identification and explanation of this diversity, at the level of the firm, was made possible through the development and use of a configurational approach, as outlined in chapter 4.

Regarding the *horizontal dimension*, the evidence presented indicates that no connection exists at all between the extent of horizontal cellularisation²⁵³ and general design orientation. Empirical data showed that the researched firms possess a high average of horizontal cellularisation (7 out of 10 firms had more than 60 % of their manufacturing facilities arranged as a cell layout) and this seems to be independent of the general design orientation applied. That is, firms applying either HC type, neo-taylorist or taylorist design orientation possess high degrees of horizontal cellularisation. This suggests that while the high degree of horizontal cellularisation supports the set-up of work groups along HC principles (and other design orientations such as the lean approach), the application of a cell layout does not imply 'automatic' human-centredness. In effect, the empirical data showed that cellular manufacturing can be structured and managed along either HC or non- HC lines. "Weg", for example, applied traditional taylorist practices at the shopfloor despite having high degrees of cellularisation in their assembly activities.

Still, the application of the cell concept in manufacturing is important for supporting HC strategies. Intra and inter cells organisational integration is supported by cellular layout in

²⁵³ Horizontal cellularisation refers to the extent to which firms apply cellular layouts. This can be from very marginal areas to complete facilities designed in the manner of cellular arrangements. In general terms, the researched firms' cells possess low computerisation levels and are highly labour intensive. They might be better described as hybrid configurations with low degrees of mechanisation in material handling terms. In the majority of cases, parts were not completed in a single cell.

addition to allowing direct workers time to perform planing, co-ordination and problem-solving activities. Worker leeway is one of the results of transferring micro planing and controlling manufacturing activities from the PPC department to shopfloor operators. This not only promotes intra and inter cell co-ordination, but also facilitates co-ordination between the PPC department and shopfloor level. These organisational arrangements, however, need to be purposefully designed and implemented as they are not an automatic consequence of the cellularisation process. The level of intra and inter cells buffers is an important factor for supporting human-centredness. Higher buffers between cells, for example, imply a lower interdependence which favours the application of HC principles, such as job rotation and group self-governance of micro planning and control of production related activities²⁵⁴. The level of buffers therefore, is a socio-technical condition that favours but does not determine human-centredness (see below).

The above findings are congruent with theoretical suggestions in terms of the socially constructed nature of organisational life. That is, intra and inter cell interdependency are constituted by the type of cell layout, organisational design and the degree of worker control over their immediate working environment. Social actors (eg workers, supervisors and middle management) working inside and around cells play a key role in the formation of buffer stocks and, hence, interdependence levels.

In the *vertical dimension*, high levels of human-centredness were found in the control and timing of direct manufacturing activities (ie transfer of both micro planning and controlling activities from PPC department or supervisory levels to shopfloor operator level occurred). This represents, in Brazil, a new management strategy to deploy personnel and to improve competitiveness. This is significant as it implies an acceptance by management of the transfer of some 'control' functions to the shopfloor in exchange for improved technical efficiency. This represents a real departure from traditional taylorist and neo-taylorist type management strategies as it suggests the devolution of responsibilities to the shopfloor²⁵⁵.

²⁵⁴ At 'vil' (the lift manufacturer) for example, almost all the plant (85 % of facilities) was arranged in a cellular layout. In general terms, 'vil' cells follow in a sequential pattern, but substantial buffers existed between them because each cell produced almost entirely a whole part (eg doors or cabins). A JIT production system was fully operational which theoretically increased interdependency. Individual cells however, possessed a significant degree of autonomy due to existing inter-cell buffers.

Conversely, in the electro-electronic component manufacturer (sie), the level of interdependence was high between cells because of the low level of buffers that existed between cells. Even though 'sie' possessed a high degree of horizontal cellularisation (80 % of facilities arranged by cell) and a JIT production management. This implied a low self-regulation level of work groups at inter-cell level.

²⁵⁵ This however, can not be equated with 'empowerment' or 'autonomy'. This development is further detailed in section 10.6.

However, lower levels of human-centredness occurred in the control of indirect manufacturing activities. The transfer of indirect manufacturing activities, such as SPC and routine maintenance to shopfloor workers, was limited due to the low level of skills of direct workers and to the unwillingness of some middle management levels to transfer crucial indirect activities such as machine set-up and NC programming. Further, the poor educational standards of shopfloor workers represents a concrete barrier to the effective implementation of some basic production engineering techniques, such as statistical process control.

Regarding organisational restructuring, firms significantly changed organisational structures and associated training practices towards product based structures. However, restructuring reward systems, career paths and worker involvement practices were, rather limited due to poor management/worker co-operative relations, low wage policies and some legal labour issues. These aspects go beyond the level of the firm and are examined in section 10.6. As experienced internationally, there has been a slowdown by management in upgrading such organisational conditions as rewards and career paths that support HCMS development.

10.5 EVIDENCE OF WEAKNESS OF GENERAL EXPLANATIONS OF HC DEVELOPMENT

A significant discovery was that many features previously identified by HC theorists (and contingency theorist), as important in influencing production systems were in fact not highly important. The degree of human-centredness in the organisational dimension was not strongly linked to either: (i) HC designed technology; (ii) product market variety and change; or (iii) a firm's characteristics.

The use of non-HC designed *technology*, for example had little effect on the implementation of HC organisational principles. While this can be credited to the low technology intensity existing in Brazilian firms, our case studies indicated that 'conventional' technology²⁵⁶ is more flexible than the mechanistic views assert. In other words, conventional technology seems to possess enough room to allow a wide range of work organisation forms, including HC. This, however, does not mean that HC designed technology is redundant in the application of HC organisational principles. Indeed, it may be suggested that HC technology is a necessary condition to fully apply HC organisational principles in highly automated settings. Hence, the

²⁵⁶ Conventional technology, in this context, is approached as non-computer-based manufacturing equipment. In the case of studied firms, conventional technology was also aged (15 year old on average).

assumption that organisational components are more important than technology components in realising MES efficiency seems to be correct because of the low profile that the 'technological' factor played in the researched firms (low intensity of AMT was common)²⁵⁷. This suggests that the 'technology factor' was not crucial in the selection of production models or for setting productivity patterns. The empirical evidence therefore do not support technological determinism arguments.

Regarding *product market* factors, the evidence suggested that HC-oriented firms operated not only in mass customised markets but also in small batch/standard product markets (though with high production variety)²⁵⁸. On the one hand, batch size was not related at all to the type of general organisational design approach adopted, specifically the adoption of the HC model²⁵⁹. Exhibit 10.1 illustrate this as Group I firms includes those firms that restructured using HC-like and neo-taylorist strategies. This insight is important for HC theory diffusion, because it suggests that batch size is not a determinant constraint to implementing HC principles.

On the other hand, *production variety or scope* seemed to be positively related to the adoption of the HC model. Studied firms that adopted HC type restructuring possess a high degree of production scope (these produce more than 100 different models of their products - see group I firms in Exhibit 10.2). This finding is not surprising as HC theory indicates that high production scope is one of the causes of higher task complexity and uncertainty, providing an incentive for the application of HC strategies. In other words, the HC approach is appropriate to cope with increasing numbers of models and product customisation.

Additionally, a connection is suggested between high PCF (product customisation feasibility) and a HC type design orientation. As illustrated in Exhibit 10.3, all firms in Group I (except 'wab') possessed high PCF and have adapted HC type design orientation²⁶⁰. Group II firms

²⁵⁷ This observation converge with international literature (cf Dean, Yoon and Susman, 1992; Haywood and Bessant, 1990; Manske, 1983; Lockett, 1990).

²⁵⁸ This finding partially agrees with Benders' (1993, 1995) empirical research in The Netherlands. For a detailed discussion of output features and a firm's design and manufacturing strategies, see chapter 9.

²⁵⁹ These findings challenge Woodward (1965), who suggests a direct linkage between production mode and batch size. That is, the smaller the batch size, the more difficult the task of co-ordinating manufacturing activities is, and the less possibility there is to (directly) control manufacturing operations. Therefore, decentralised (eg HC) strategies suit those firms better. Conversely, the larger the batch size, the simpler the routine task and co-ordination activities are; and, the easier it is to exercise control over manufacturing operations. Taylorist like strategies are, therefore, better suited to mass-production firms.

²⁶⁰ Whether high PCF is a cause or effect of HC type design orientation, is an open research question not answered in this study.

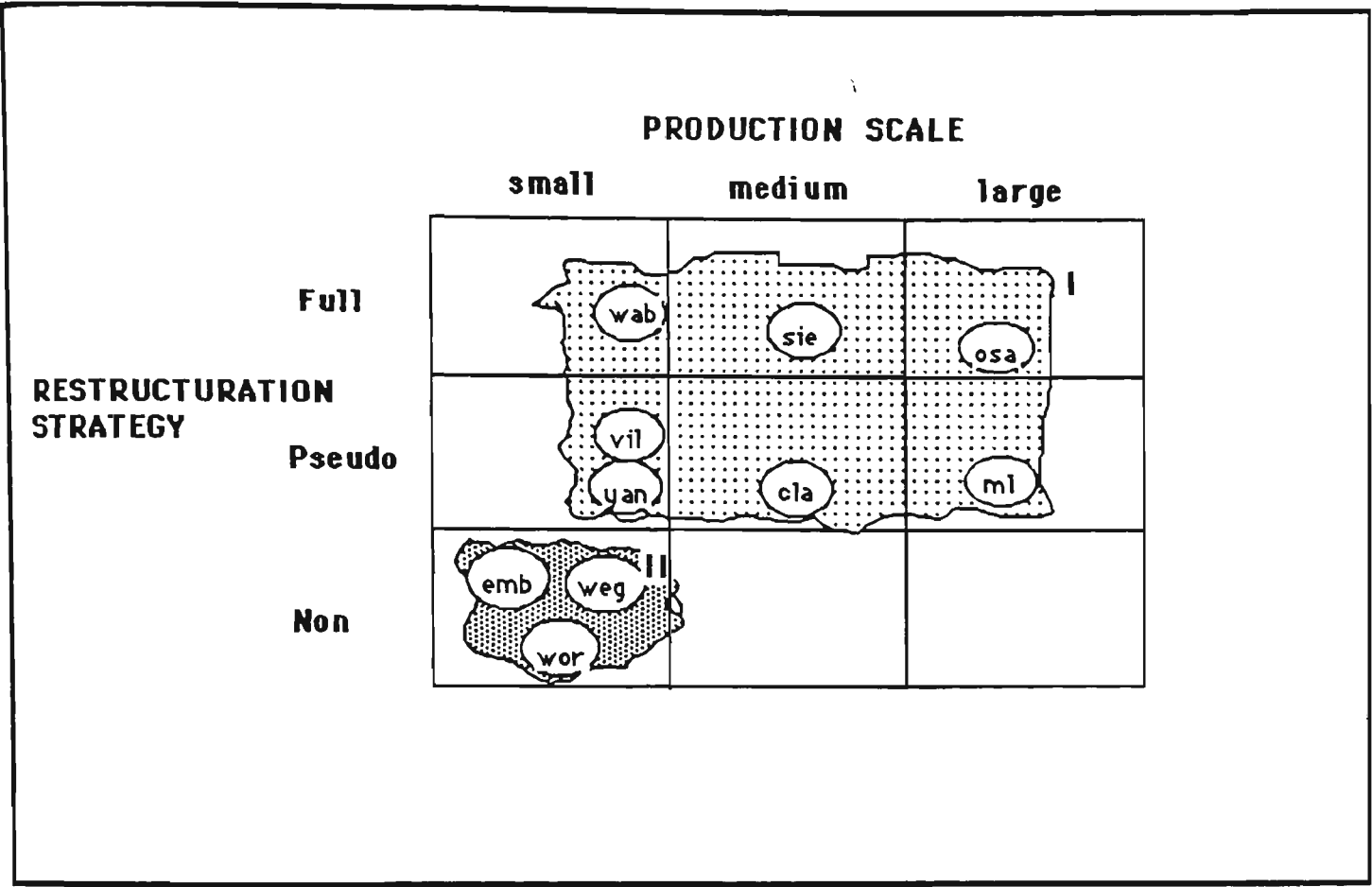


EXHIBIT 10.1: General Design Orientation and Production Scale

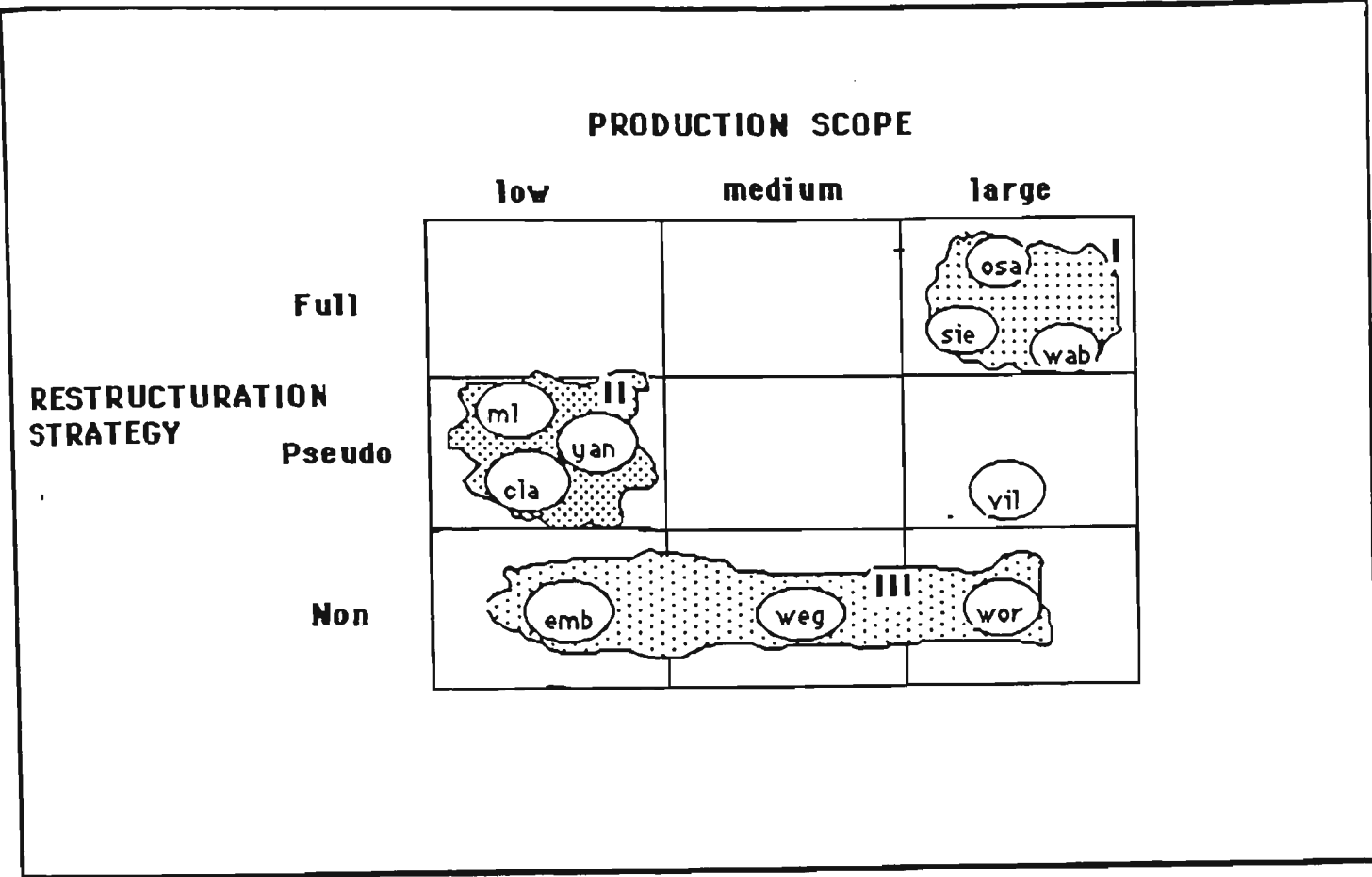


EXHIBIT 10.2: General Design Orientation and Production Scope


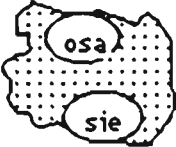



		PRODUCT CUSTOMISATION FEASIBILITY		
		small	medium	large
RESTRUCTURATION STRATEGY	Full			
	Pseudo			
	Non			

EXHIBIT 10.3: General Design Orientation and Product Customisation Feasibility

further support this claim as a sharp relation between the use of tayloristic and neo-tayloristic restructuring strategies and low/medium levels of product customisation feasibility was found²⁶¹.

A number of specific additional points can be made.

First, the firms' product-market profile did not adhere to current organisational theory in terms of matching task complexity (and its associated high degrees of uncertainty and interdependence) to HC-oriented work and organisational structure forms. Organisational arguments, therefore, do not find empirical support in the present study²⁶². The design and manufacturing strategies applied by studied firms did not accurately follow established business rational (in terms of product profile possessing 'appropriate' design and manufacturing strategies).

Second, the empirical data did not support 'new market conditions' arguments, since higher production scope did not necessarily result in firms adopting advanced managerial practices. Indeed whilst higher production scope is evident, it needs to be understood not only as an increase in variety (number of models), but also as entailing the minimisation of the basic platform from which a high variety of 'different' models are drawn.

Third, the productivity data indicated an independent relation between the production model adopted and productivity levels.

Firm features such as ownership and size, as well as production features such as target market, production scale, cell type, and the extent of horizontal cellularisation, all seemed to be weakly connected to the application of HC principles. This supports, rather than constrains, the further diffusion of the HC model (as applied in Brazil)²⁶³.

²⁶¹ It is necessary to note that PCF is only one dimension of the generic 'differentiation' strategy used to gain competitiveness. There are other strategies such as designer brand image, technology, features, customer service and dealer networks, that can be used to increase product differentiation (Porter, 1980). Nevertheless, product customisation, seems to be one of the most direct ways of obtaining differentiation, out of the application of AMT. It follows that the general design orientation seems to be independent of the strategy of differentiation chosen. However, reform along HC lines supports differentiation by product customisation.

²⁶² In general terms, the above findings support the processual approach to technology and organisational change developed in chapter 2. This approach recognises the strong limitations on technological determinism, the configurational nature of both technologies and organisations and the messy partial nature of organisational change.

²⁶³ It should be noted that earlier research suggested the existence of HC type work organisation in Brazil in the capital goods and automobile firms. See for example Meyer-Stamer et al (1991), Silva (1991) and Leite (1994).

Exhibit 10.4 summarises the research findings regarding key firm features such as ownership, location, size of firm and market target. The evidence does not suggest any relationship between the firm profile and the type of design orientation applied, with the notable exception of geographical location. The ownership factor seems to have very little effect on the restructuring strategy applied, since, in foreign owned firms, the restructuring strategy was more a result of local initiative than of head-quarters push. This suggests that labour markets and the general state of industrial relations do influence the achieved degree of human-centredness. All firms that restructured along HC principles were located in rural areas where trade union activity was not very efficient, in terms of providing workers with guidelines regarding their possible losses or gains, regarding restructuring. This does not mean that the wider industrial relation context is the only factor, but certainly it is an important consideration, when the decision is made regarding types of restructuring to be applied²⁶⁴ (this point is further develop in the next section). Other factors such as ownership, firm size and market target did not seem to influence the general organisational design orientation adopted by researched firms²⁶⁵.

Industrial 'globalization' arguments are undermined by the above findings, as the evidence presented suggest that there exists a series of complex national factors beyond internationalisation of the economy (ie higher capital mobility due to financial de-regulation). Despite the recognition of a process of wide spread internationalisation of industrial production practices (Elger and Smith, 1994) and the further internationalisation of the economic system of co-ordination and control (by denationalised TNCs) (Whitley, 1994), this study suggests that national institutional forces seems to be more powerful in terms of selecting the appropriate production model. This point is explained in the next section.

10.6 THE PERSUASIVE INFLUENCE OF BRAZILIAN NATIONAL CONDITIONS

This ambiguous pattern of HC development in Brazilian firms reflects a national set of facilitating and constraining factors. The economic path taken by Brazil since early

²⁶⁴ This is significant, as it reinforces the view of the literature with regard to location factors and workers' associations bargaining power. Kenney and Florida (op cit) for example, have clearly indicated that one key premise for success of Japanese transplants in the United states, is related to location: greenfields plants are all located out of large industrialised areas.

²⁶⁵ The current view that TNC branches performing in developing nations are forerunners in adapting innovation in general, is not supported by our empirical data.

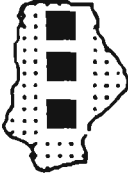



















Type of restructuration	Firm	Ownership	Location	Size	Market target
Full	OSA	●		***	
	SIE	○		**	
	WAB	○		*	
Pseudo	VIL	●		n.a.	
	ML	●		***	
	CLA	○		***	
	YAN	○		*	
Non	EMB	●		***	
	WOR	○		*	
	WEG	●		***	
<div> <div> ● national ○ foreing </div> <div> ■ in-land □ metropolitan </div> <div> *** large ** medium * small </div> <div>  overseas  domestic </div> </div>					

EXHIBIT 10.4: General Design Orientation and the firms' features

industrialisation, together with substantial changes in both industry policy and developmental orientation, have resulted in a general macro contextual industrial setting which, in some aspects, support the adaptation of the HC model at firm level and in other aspects constrains HC principles implementation.

Supporting macro contextual factors includes: an indigenous technological capability (ITC) (that involves R & D capacity) installed in several key industries; the existence of a well endowed and developed tertiary educational sector in selected areas; and a privately funded and controlled vocational training system that seems efficient for supplying skilled technicians to successful national firms and strategic key industries²⁶⁶. An additional factor that supports the utilisation of HC principles at firm level is the verification that, despite the existence of non-favourable industrial relations at general level, firms classified in the present study as HC oriented have already developed specific human resource mechanisms to try to overcome socio-political barriers (eg relative job stability and strong investment in training). This suggests that a favourable socio-political environment is not necessarily externally given to the firm, but can also be internally built, an indication of a managerial capacity to search and apply new organisational forms²⁶⁷. While this existing capacity is limited to successful national firms and key strategic sectors, their 'model' role, especially in relation to direct suppliers and customers, is important for further diffusing HC principles.

However, there are a number of constraining macro contextual factors. An important limitation perhaps, is the fact that ITC is limited to specific industrial sectors, so gains are distributed mainly to key strategic industries and successful national firms, leaving the majority of firms without technological support. Further, public educational and vocational training systems are lacking at primary and secondary levels. This is a factor that might severely constrain further improvements in the industrial base and, addressing it, is a long term process. Moreover, the non-favourable general industrial relations environment is a factor that severely constrains the diffusion of the HC model, as at least a minimum degree of management/worker trust is needed. The lack of a clear and stable industry policy also prevents managerial cadres from changing current organisational practices. As such, taylorist and fordist manufacturing practices remain dominant in Brazilian firms.

An additional word regarding industrial relations factors is necessary since they played a

²⁶⁶ However, this is true only in the context of slow economic activity. If further economic activity occurs, a shortage of skilled manpower is likely to occur.

²⁶⁷ It should be noted nevertheless, that this seems to be true only in the short term. Long-term favourable socio-political context seems to be crucial for achieving sustained competitiveness (cf, Meyer-Stamer, 1997).

prominent role in both the selection of the production model and the shaping of HC-oriented firms. HC-oriented firms have, a key common feature: all were located in country areas. This is significant because, unlike metropolitan industrial zones²⁶⁸, in country areas TU's have lower bargain power, their efforts are dispersed, they are not well organised and labour is docile. The liberal policies applied since 1990 generated a domestic economic recession that ended in 1993. Adverse contextual conditions nevertheless, continue for organised labour after this date as macro institutional reform did not involve the implementation of compensatory policies for activating labour markets²⁶⁹. Domestic economic industrial recession not only triggered the need to restructure shopfloor activities, but also provided the political bargain power for the management during the implementation of the organisational reform as it was accompanied by a wave of mass-dismissals and new inter-firm arrangements (eg. sub-contracting) that weakened labour's bargain power. Additionally, the paternalistic feature of Brazilian management favoured a non negotiated implementation process of HC principles. Not only implementation was top-down but also neither TU's nor workers were involved in the 'design' or implementation process.

The state of labour markets in Brazil is another factor that helps to explain why (and how) HC principles were applied. In general terms the labour markets in Brazil seems to be negative for workers and to a lesser extent, for industries. On the one hand, Brazilian labour markets favours the creation of a large number of low waged and low skilled jobs, hindering the achievement of high productivity levels. Furthermore, hire and fire practices are common since prevailing institutions favours both short term contracts and low cost dismissals. In turn, this favours low investment in training, low skill levels in the firms, poor work safety and health conditions and so non-co-operative capital-labour relationships. Highly segmented labour market²⁷⁰, high turn-over rates²⁷¹ and high unemployment rates in the industrial sector (industrial work fell by 35 % since early 1990)²⁷² are additional features of the Brazilian

²⁶⁸ The automobile industrial sector located in Sao Paulo's ABC area is an example of advanced Trade Unionism in which technological/organisational developments are being negotiated and results are being positive, in general terms, for both sides (cf, Leite, 1997).

²⁶⁹ For details see Leite (1997).

²⁷⁰ In average, 52 % of labour force is (formally) employed in the six largest metropolitan regions, 25 % are informally employed and 23 % are independent.

²⁷¹ As commented in the theoretical part, two institutions, unemployment benefits for dismissals, favour high-turn over. In 1989 for example, annual turn over was 39,66 and in 1993 32,81 (Camargo, 1996:31).

²⁷² It should be noted that unemployment rates in Brazil are low (eg, 5,5 in 1995), compared to international standards (Camargo, 1996). Unemployment rates were for example 6,63 in 1981; 5,1 in 1985, 4,13 in 1989 and 5,5 in 1995 (Camargo, 1996, *Jornal do Brasil*, 1996). These rates are low as include 35 % of industrial unemployment that occurred since early 1990's.

labour markets. On the other hand, this situation favours in some extent firms since it promotes high flexibility in real wages and turn-over terms; so firms are able to easily obtain numerical flexibility²⁷³.

Above labour market features assist to explain the implementation of the HC model in country areas and highlight a key political dimension of the organisational restructuring process. In spite of the lack of skilled workers and adequate training institutions in country areas, firms opted for applying HC organisational design orientation because both the docile nature of manpower in country areas and the small influence of TUs. This, seems to be a key factor for the relative success of the adaptation of HC concepts. In this way, key firm conditions for the successful utilisation of HC principles, such as the existence of worker's loyalty, co-operation and consent, were almost assured in country areas²⁷⁴. Case studies suggested that shopfloor workers in country areas, 'co-operated' regardless of working conditions. Allied to this, the slightly above average wages that HC-oriented firms paid was another reason for workers to accept managerial rule²⁷⁵. Thus, it can be suggested that the state of labour markets seems to be an important barrier to fully implement HC principles in Brazilian firms in settings in which TUs were active and well organised.

Prevailing macro conditions therefore promoted a highly heterogeneous application of HC principles in their basic forms and extents. Domestic macro contextual conditions enabled management to underscore key organisational features of the HC model such as wage system improvement and career path reforms, on the one hand. On the other hand, shopfloor work structures²⁷⁶ and firm level organisational structure²⁷⁷ components have medium to high level

²⁷³ For details about the state of Brazilian labour markets see Camargo (1996).

²⁷⁴ Because of Labour Laws, firms in Brazil need to have an associated trade Union. Nevertheless, in country areas TUs have a very low profile. This enables firms to behave as if there were no trade Union. That is, firms apply "modern" Human resource practices in order to assure loyalty and cooperation required to apply alternative manufacturing concepts. This strategy nevertheless is not free of problems. (for the case of non-union firms in the United Kingdom see Mcloughlin and Gourlay, 1994).

²⁷⁵ As wages are in general low in Brazil, even a small difference in wages represent an important reason for shopfloor workers to try to maintain their job.

²⁷⁶ This involve factors classified as 'direct manufacturing indicators' and refers to key PPC related planning and controlling activities that are susceptible to transfer from PPC department to shopfloor level. They do include: manufacturing organisational structure, production order issuing, means of production control, responsibility for output, work station set up, detail scheduling, production follow up.

²⁷⁷ This involves a set of factors that reflects the firm's organisational structure and provide the technical and social systems of production and general infrastructure conditions for the implementation of HC principles at the shopfloor level. They do involve: participation, skills, training, reward system and career path.

of human-centredness²⁷⁸.

The above challenges Auer and Turner (1992)'s hypothesis regarding the need of 'favourable' macro structural conditions for implementing HC principles at the firm level. Rather, empirical evidence presented has suggested that despite the existence of 'weak' institutions (eg, insufficient educational and training systems), it is still possible to set up HC-oriented work and organisational forms. Case studies have also indicated that macro contextual conditions, and specifically industrial relations conditions, seem to be a crucial element in the decision of the implementation of HC principles. In other words, rather than economic, technical or market factors, political factors continue to be decisive for selecting the appropriate production model. Thus, conversely to conventional wisdom, it can be suggested that the combination of strong organisations and weak institutions might allow the successful implementation of alternative forms of work and organisation (at least in the short term)²⁷⁹.

10.7 BRAZILIAN HC-ORIENTED FIRMS IN PERSPECTIVE

In general terms, it is possible to suggest that while the Brazilian HC oriented style is in its very early stages, empirical data showed a sharp HC oriented strategy that is clearly different from other NPCs, such as the Japanese model of lean production²⁸⁰. The HC-oriented firms studied showed the feasibility of setting up a new strategy in relation to both technical and labour management deployment in Brazil. That is, a paradigm change in manufacturing policy is feasible. The 'model' role that HC-oriented firms possessed, is a strong sign that the HC model can be adopted in the Brazilian context²⁸¹.

²⁷⁸ Worker involvement occurred in HC-oriented firms, but in a limited form due to the following contextual conditions existing at the time of data collection. The domestic economic recession, the shrinking of the labour force in the manufacturing sector, the paternalistic and authoritarian style of Brazilian management and the low trust level existing between management and workers.

Reward systems and career paths were also changed to a small extent. Reasons for this were directly linked to the particular institutional conditions of Brazil. For example, current labour legislation, that dates from the 1950's, does not encompass the idea of variable rewards, let alone a group based reward system, and productivity and profit distribution gains schemes are rarely implemented by firms.

²⁷⁹ This finding echoes the latest developments in Germany (cf Braczyk and Schienstock, 1996).

²⁸⁰ The clear differentiation among New production Concepts (NPCs) such as the Japanese lean model and HC views is necessary as different approaches bring different implications for both workers and firms. Some research on 'effects' of the introduction of new technology and new organisational forms (cf Leite, 1992) have failed to clearly identify the type of production model under study.

²⁸¹ Two HC oriented firms were, by the time of data collection, already performing their 'model' role, diffusing their manufacturing strategies to several visiting firms, specially customers and suppliers.

Converging with international trends, restructuring strategies followed by the researched firms, illustrate that the choice is not between the application of one strategy *or* another. Rather, the research findings suggest that it is possible to implement different types of restructuring at the same time at different organisational levels. What is not clear is how, why and to what extent different restructuring strategy combinations are competitive and feasible to implement and its implications for both management and labour. This might become a key issue in any research agenda focusing on modern manufacturing systems.

Nevertheless, it is necessary to admit, paraphrasing Boyer (1994), that the application of the HC model in Brazil is an island in an Ocean of taylorist and Fordist traditions. Pace of adoption seems to be slow as macro contextual conditions constrain rather than support its implementation. Long term economic and social outcomes are still to be seen as the application of the HC model seems to be in its very early stages. The application of HC principles in researched firms seemed to be more the result of a borrowing from different models than the result of a designed strategy. Borrowing because none of the HC-oriented firms (and neo-taylorist oriented firms as well) applied solely HC concepts. Rather, combined to HC organisational forms and work practices, different elements of alternative NPCs such as teamwork Japanese style and SPC were combined. This view supports two insights. First, Brazilian firms are in a period of testing alternative production models. Second, the dynamic evolution of production models is under way and seems to involve the adaptation of both HC type concepts and Japanese principles to Brazilian macro contextual conditions.

A key difference in applying HC principles between European and Brazilian firms seems to be their different immediate operational goals. While in Germany the application of HC principles was directed towards the full utilisation of technology's flexible potential, evidence presented here indicate the application of HC principles in Brazil seemed to be concerned more with the flexible deployment of personnel than of technology. Two reasons support this insight. Firstly, the application of HCM did not seem to be related to technological factor, as there exists a low level of technology intensity in Brazilian firms. Secondly, pressed by the opening of the Brazilian economy and internationalisation of production, firms needed to achieve economies of scale and/or scope²⁸². Thus, it is possible to suggest that, HC-oriented firms applied HC principles as a means of acquiring 'organised human capabilities' in order to respond to the scale and scope market demands²⁸³.

²⁸² As Chandler (1990: 24) suggested, 'the actual economies of scale or scope, as determined by throughput, are organisational. Such economies depend on knowledge, skill, experience, and teamwork - on the organised human capabilities essential to exploit the potential of technological processes'.

²⁸³ This view converge with other research findings: 'Whilst there are undoubted technological (such as software compatibility) and economic problems, the major are of difficulty lies in the ability of people and organisations to adjust and adapt. The key point is that flexible manufacturing will require flexible

An important element in this strategy seems to be the way labour was managed. While the 1940-1990 period witnessed a 'labour restriction' strategy, empirical data indicates that from the early 1990s there seems to be a trend towards the application of a 'labour development' strategy. That is, in order to achieve operational results, firms were providing further training to workers so they could apply/use new industrial engineering techniques. Whilst in Brazil this labour development strategy seems to be shy (compared to European practices), it really can be qualified as a major departure from Brazilian industrial culture as taylorist and Fordist type industrial practices are deeply entrenched. Additionally, because both the low wage feature of the Brazilian labour market and the low level of AMT utilisation, it seems to be more economically feasible for firms to invest in organisational based restructuring (such as NPCs) than in technology based restructuring.

It should be noted that both macro contextual and firm level explanations provided above regarding the application of HC principles, seem to apply in significant extent to other alternative production systems (such as the Japanese model). These models can, as with any other model, be totally or partially adopted and can even be adapted to local conditions in a wide range of forms. In other words, operational concepts and techniques can be applied selectively in particular areas or at the firm wide level. Each dimension of the chosen model can, in turn, be implemented in a wide range of forms and to different degrees. As different firms possess both different operational 'needs' and market targets and as well as being located in particular regions with particular labour market features, they might apply different models to different extents. So, an important question is not which model is superior, but how different models are selectively applying different principles at different organisational levels and, which mix of macro contextual conditions support or constraint the adaptation of new production concepts.

This dissertation has contributed to the understanding of the HC approach in semi-peripheral nations. It has also helped the comprehension of the concept of production systems (see Chapter 3). A deep understanding of the concept of production systems helps to interpret particular reality, to outline firm level strategies and to inform discussions on industrial policies.

Production systems were conceptualised as the point in which organisational, technological, managerial and political processes converge in order to transform information/raw materials into product and services. Those processes occur in specific economic regions which have

particular institutions (such as tax and labour laws, education and training systems) which, in turn, are developed in different degrees. It seems to be that congruence between micro and macro level processes promotes technical efficiency of the production system. Nevertheless, because organisational and technological decisions encompass political issues, the congruence between micro and macro level processes is complex.

In order to understand this multi-dimensional concept, different theoretical approaches were applied at different level of analysis. At the macro level, the institutional approach was used (see Chapter 5) in order to understand the influence of macro contextual factors on firm level developments.

At the micro level, a configuration/process approach was used in order to comprehend the heterogeneous pattern of HC principles application. Informed by the social construction of technology concepts, the configuration/process approach treats production systems as sets of inter-related parts. Each part has a specific function and can change over time. Different parts also possess different degrees of interdependency which can change over time. This means that technological, organisational and user components can be configured (designed) in a limited number of ways. During the implementation process however, social actors might reconfigure the original design in order accommodate their specific goals and interests.

It should be noted that only the combination of the two levels of analysis (both micro and macro) allowed a better understanding of the social, technical, organisational and political developments that occur during the implementation of HC principles. The sole utilisation of one framework (either micro or macro) seems to be insufficient to deal with this task. For example, in order to decide the orientation of the production model to apply (e.g. towards Japanese Lean style or towards HC orientation) empirical evidence has showed that both labour markets and capital-labour relations seems to play a more important role in semi-peripheral nations like Brazil than in highly industrialised nations. This is because the goals and resource availability at the level of the firm, such as degree of usage of highly automated technology, firm level goals for resource deployment (e.g. towards labour development to obtain labour flexibility or towards new labour deployments to obtain full utilisation of highly automated technology), are different in the semi-periphery and in highly industrialised nations. Different firm level orientations are explained by the different macro level institutional conditions. The degree of efficiency of both labour laws, Trade Unions and professional training systems for example, narrow the choices made at the level of the firm.

Finally, it should be noted that, because both the exploratory character of this study and the changing face of Brazilian manufacturing conditions, no conclusive statements about the

future of human-centred manufacturing in Brazil can be drawn. However, it is evident that options for production systems do exist and it is feasible to apply alternative production models in a semi-peripheral nation like Brazil in terms of micro and macro structural factors. Whether or not Brazil will be a nation with a viable economic future seems to be more a question of societal action that goes beyond the simple application of any fashioned managerial fad and intensive application of computer-based technologies. Even acknowledging its limitations, the HC model seems to contribute to addressing what Schumacher (1976) called the 'production problem'²⁸⁴ because it supports addressing two key socio-economic problems, that seems to be common to all peripheral and semi-peripheral nations: Industrial competitiveness and social equality. Supporting and promoting the HC model therefore, refers not only to the application of specific techniques or methods at firm level, but also to a pattern of resource distribution. Contributing to address industrial competitiveness and social equality therefore is relevant since economic historian Eric Hobsbawm (1995) suggested that, unlikely the post-war period, the 1990's is an era in which the principal world problems are related more to resource distribution than to resource creation.

²⁸⁴ That is, both the type of production system adopted, and its associated socio-economic institutions, influence the form of resource creation and distribution.

APPENDIX A

SCIENCE AND TECHNOLOGY STUDIES DEPARTMENT (STS)

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ROTEIRO DE ENTREVISTAS: ASPECTOS ESTRATEGICOS

I. INFORMACOES GERAIS

1. Nome da empresa: Localizacao (101)
Capital:

2. Principais produtos (141)
nome % do total % valor agregado na firma

3. Evidencia da eficiencia da empresa (102)
- intangivel (eg. aumento da fatia de mercado da firma, ingresso a novo mercado)
- tangivel:

ano	1987	1992
numero total pessoal		
valor total de mercado dos produtos fabricados (US\$)		
valor total equipamentos de capital (US\$)		

4. Capacidade tecnologica da firma (projeto e fabricacao dos principais produtos) (105)
(qualificar de 1 a 5)¹

- licenca estrangeira para produzir no pais
- melhoramentos em projeto estrangeiro
- melhoramento maior de projeto estrangeiro
- capacidade para fazer projetos proprios
- capacidade para competir internacionalmente

*5. Fontes de conhecimento tecnologico (106) (qualificar de 1 a 5)

- proprio grupo da firma
- informacoes de clientes/fornecedores
- acordos especiais com empresas estrangeiras
- instalacoes de P&D² externas a empresa
- instalacoes de P&D internas a empresa
- outros (especificar)

6. Esforco inovativos da empresa: investimento em P&D:(107) (qualificar de 1 a 5)

- pesquisa basica
- pesquisa aplicada (projeto de novos produtos;engenharia de producao; engenharia de processos)
- outros (marketing, distribuicao etc.)

1 1= nao/pouco/nunca; na minoria dos casos; 5=sim, sempre,muito, na maioria dos casos

2 P&D: Pesquisa e desenvolvimento

7. Operacoes de projeto versus operacoes de manufatura (108)
-% do valor agregado no projeto
-% do valor agregado na manufatura
- *8. Fator cultural (209)
-Qual e a sua opiniao a respeito da atitude do trabalhador Brasileiro em relacao a seu trabalho ?
9. Organograma da empresa (210)

II. ASPECTOS ESTRATEGICOS DA EMPRESA

10. Fontes de competitividade da empresa para: (i) mercado interno; (ii) mercados internacionais) (qualificar de 1 a 5) (110)

	para mercado nacional	para mercado exterior
projeto do produto		
engenharia do processo		
eficiencia na producao		
preco		
rapida resposta a demanda do mercado		
custo da mao-de-obra		
qualificacao do pessoal		
tecnologia utilizada		
conceitos organizacionais utilizados		
estimulos do governo (ex. incentivos p / treinamento, P&D)		
relacoes com fornecedores e/ou clientes		
protecao de mercado		
outros		

Condicoes macro-institiucionais que favorecem/prejudicam a competitividade da empresa.

11- 27 Entre os seguintes fatores externos apresentados, quais afetam mais (e como isto acontece) as decisoes tomadas na sua firma com respeito a estrategia do projeto do produto; producao; recursos humanos. (i) usar escala de 1 a 5; (ii) Explicar os mais importantes fatores (111)

	Organizacao	Tecnologia	Recursos Humanos
condicoes macro-economicas ³			
sistema educativo nacional			

3 ex. inflacao, taxa de cambio, juros.

sistema de treinamento nacional			
mercados de trabalho ⁴			
incentivos do governo ⁵			
relacoes industriais ⁶			
politica industrial ⁷			
infra-estrutura tecnologica ⁸			
concorrencia nacional/internac.			

27a. No presente estudo estao incluidas so um pequeno grupo de empresas selecionadas consideradas avancadas em termos de (i) estrategia de mercado; (ii) forma de utilizar a tecnologia; (ii) forma de se organizar (iii) forma de gerenciar os recursos humanos. Voce acredita que estas empresas possam servir de modelo para outras firmas ? (336)

27b. Quais as principais diferencas entre este grupo de empresas e 'outras' empresas ? (338)

28. Sua firma esta envolvida em alguma 'alianca estrategica' com outras firmas ou instituicoes, com respeito a P&D, marketing ou atividades de treinamento, manufatura ? (135)

III. ASPECTOS ORGANIZACIONAIS

32. A utilizacao de algumas novas formas organizacionais na empresa⁹ esta dirigida para : (qualificar de 1 a 5) (138)

- reduzir o tempo total de fabricacao
- reduzir inventarios (inventarios em processo, e finais)
- aproveitar melhor a utilizacao do pesssoal da fabricacao
- aproveitar melhor a utilizacao dos equipamentos
- melhorar a qualidade dos produtos
- responder rapidos as mudancas de demanda
- outros (especificar)

34. Qual dos seguintes fatores internos a empresa tem maior prioridade? (qualificar de 1 a 5) (140)

- o prevalente 'ambiente' interno de relacoes industriais
- o uso de novas formas organizacionais
- a presente politica de treinamento
- a existencia de pessoal altamente qualificado no projeto, engenharia e producao
- a existencia de tecnologia de ponta
- a forma como a tecnologia e utilizada

4 a nivel de engenheiros, gerentes, trabalhadores qualificados

5 ex. incentivos para P&D, treinamento, investimento em equipamentos de capital

6 em termos de (i) legislacao laboral existente e, (ii) atitude dos trabalhadores com a firma

7 ex. menores tarifas para importacoes

8 ex. disponibilidade no pais de tecnologia e conhecimentos tecnicos/organizacionais avancados.

9 Por exemplo grupos de trabalho, celulas de producao descentralizadas etc.

- a estrutural organizacioanl geral da empresa
- a estrutura da tomada de decisoes
- a forma como o pessoal de producao e motivado e recompensado (ex. sistema de carreira profissional, o sistema salarial), as condicoes de emprego oferecidas.
- outros (especificar)

35. Definir a politica de recursos humanos na empresa em termos de atitude da empresa em relacao ao pessoal de producao direto. (248)

36. Os esforços tecnologicos da empresa estao orien ados para: (137)
(qualificar de 1 a 5)

- aumentar a variedade de produtos a fabricar
- desenvolver novos produtos
- alongar a capacidade de utilizacao do equipamento existente
- utilizar plenamente a capacidade da planta
- outros (especificar)

37. Economias de escopo (142)

ano	1987	1992
variedade ¹⁰		
variabilidade ¹¹		
% partes prontas ¹²		
% partes compradas ¹³		
% partes encomend-1 ¹⁴		
% partes encomen-2 ¹⁵		

38. Estrategia de mercado (%) (143)

	produtos estandarizados	produtos customizados
no pais		
no exterior		

39. Concorrencia (%) (144)

	produtos estandarizados	produtos customizados
no pais		
no exterior		

39a. Condicoes atuais do mercado (346)

	nacional	exterior
crescendo		
estavel		

10 numero de diferentes produtos manufaturados no ano referido

11 % de produtos totalmente novos

12 % de partes comuns a outros produtos existentes na empresa ou de modelos previos

13 % de partes compradas de fornecedores e que foram desenvolvidas (projetadas e produzidas) totalmente pelo fornecedor

14 % de partes encomendadas a fornecedores , mas onde o projeto geral foi desenvolvido pela firma e o projeto detalhado foi desenvolvido pelo fornecedor

15 % de partes encomendadas, mas que foram totalmente projetadas (projeto geral e detalhado) na empresa e so fabricadas no fornecedor

declínio		
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39b. Qual a natureza do seu segmento de mercado em termos de níveis de concorrência (444)

	nacional	exterior
forte		
moderada		
fraca		

39c. O mercado da empresa é dominado (+ 75% do mercado) por: (445)

- (i) menos de 4 firmas
- (ii) menos de 10 firmas
- (iii) mais de 10 firmas

39d. Tempo de vida (projeto) dos maiores produtos (348)

- menor de 3 anos
- entre 4 e 10 anos
- maior de 10 anos

39e. Quais são as características dos principais produtos da empresa que os diferenciam no seu segmento do mercado (310)

39f. Que proporção (%) do seu equipamento de produção foram (i) projetados na própria empresa; (ii) construídos na própria empresa. (338)

39g. Existem na firma estratégias formais explícitas (escritas) com respeito à aplicação de 'fatores humanos'¹⁶ para o projeto desses equipamentos ou processos de produção?

39h. Existem na firma estratégias informais (não-escritas) com respeito à aplicação de 'fatores humanos' para o projeto desses equipamentos ou processos de produção?

39i. Que critério foi adotado para justificar a adoção de novas tecnologias? (340)

39j. Após a implementação da tecnologia, que critérios e medidas foram utilizados para avaliar os benefícios da tecnologia? (341)

40. Fornecer prioridade de 1 a 5 para os seguintes fatores (145)

-principal fonte de competitividade da empresa:

- preço
- rapidez de resposta ao mercado ou disponibilidade de produtos
- qualidade do produto

-estratégia de manufatura:

- planejamento da produção 'forte'
- produção contínua (não máquina parada)
- organização logística efetiva
- base de dados de engenharia confiável
- ênfase no controle central da produção
- rapidez na reorganização de operações de manufatura para atender mudanças de demanda

- estrategia do desenvolvimento no projeto de produtos
 - projeto de produtos não é prioridade
 - desenvolvimento de projetos em forma modular
 - rapidez no desenvolvimento do projeto
 - rapidez na reorganização do desenvolvimento do projeto para atender mudanças de demanda
- estrategia para uso de CAD
 - uso de CAD para apoio a manufatura (eg. projeto de ferramentas, layout e moldes)
 - CAD para projeto (construção) de novos produtos
 - CAD para análise de engenharia (FEA), simulação
 - CAD para gerar programa de controle numérico
 - CAD para desenvolver produtos de forma modular
 - CAD para rapidez de desenho (detalhe, cópias)
 - CAD para gerar listagem de materiais/partes
- prioridade do projeto do produto com relação a manufatura
 - projeto (conceito, análise, projeto e documentação)
 - engenharia industrial
 - planejamento da produção
 - manufatura
- Em que medida as atividades realizadas na etapa do desenvolvimento do produto facilitam as seguintes áreas de manufatura:
 - engenharia industrial
 - planejamento da produção
 - manufatura
 - outros

41. Como as estratégias adotadas para o projeto e manufatura estão relacionadas com o mercado da empresa, a atual concorrência e atuais condições macro-econômicas do país. (147)

42. Quais foram os principais fatores internos na firma que a levaram implementar novas formas organizacionais (1-5) (149)

- melhora a produtividade através de melhor utilização de maquinário
- melhora da produtividade através de melhor serviço do pessoal
- favorecer a co-operação do pessoal da produção
- melhorar qualidade dos produtos
- pessoal da produção não co-operativo
- melhorar o controle do processo de produção
- utilizar melhor as qualificações do pessoal da produção
- facilitar mudanças rápidas na produção devido a condições incertas de mercado

42a. Quais os principais fatores externos a firma que a levaram a implementar novas formas organizacionais (1-5) (349)

- pressões de mercado
- problemas com a força de trabalho
- aumento de custo de máquina
- aumento de custo da mão-de-obra

43. Quais as principais barreiras para implementar (introduzir) essas novas formas organizacionais (150)

Relacoes da firma com seus fornecedores e/ou clientes

*44. Quantos fornecedores de materia prima, partes, componentes tem a firma ?
Especificar % de fornecedores nacionais e estrangeiros. (151)

45. Tempo de relacionamento com fornecedores/sub-contratores

Tempo de Relacionamento (anos)	% de fornecedores
0 - 2	
2 - 5	
+ 5	

46. A sua firma fornece algum tipo de assistencia tecnica para fornecedores e/ou sub-contratores ? (154)

47. A sua firma fornece algum tipo de assistencia organizacional para fornecedores e/ou sub-contratores ? (155)

48. A sua firma participa de alguma forma na propriedade ou capital de seus fornecedores e ou sub-contratores ? (156)

*49. Tamanho dos fornecedores/sub-contratores

Numero de empregados	% de fornecedores
0 - 99	
100 - 500	
+ 500	

*50. Quantos maiores clientes a firma tem ? (% de clientes no pais e no exterior) (158)

51. Tempo de relacionamento com clientes. (159)

Tempo de Relacionamento (anos)	% de clientes
0 - 2	
2 - 5	
+ 5	

52. A sua firma recebe algum tipo de assistencia tecnica dos seus clientes principais ?
Explicar. (160)

53. A sua firma recebe algum tipo de assistencia organizacional dos seus principais clientes ? (161)

54. Algum(s) dos seus principais clientes participa de alguma forma na propriedade ou capital da sua empresa ? (162)

55. Tamanho dos maiores clientes (163)

Numero de empregados	% de maiores clientes
0 - 99	
100 - 500	
+ 500	

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ROTEIRO DE ENTREVISTAS: RECURSOS HUMANOS

56. Definir a politica de recursos humanos na empresa em termos de atitude da empresa em relacao a (i) media gerencia; (ii) pessoal tecnico na producao/projeto: (iii) pessoal direto da producao . (248)

57. Quais sao os objetivos principais da politica de recursos humanos para (i) media gerencia; (ii) pessoal tecnico na producao/projeto: (iii) pessoal direto na manufatura. Que passos concretos esta tomando a empresa para atingir tais objetivos ? (164)

	media gerencia	tecnicos	producao direta
melhorar o nivel de qualificacao			
balancear niveis salariais com desempenho no servico			
balancear nivel salarial com qualidade/quantidade produzida			
balancear nivel salarial com desempenho global da firma			
minimizar custos de mao-de-obra			
maximizar treinamento disponivel			
promover desenvolvimento profissional (cargos)			
evitar problemas com mao-de-obra			
providenciar melhores condicoes de emprego			
proveer boas condicoes de trabalho (nao-tangiveis)			

57a. Que acoes concretas a firma esta tomando para atingir as metas acima ? (164)

58. Existe alguma conecao entre a utilizacao de novas formas organizacionais¹⁷ e a atual politica de recursos humanos ? (264)

*59. Numero de pessoal na empresa.

(165)

Area	numero funcionarios	
Projeto de produto		
Engenharia		
Manufatura		
Outros (marketing, financas, vendas)		

59a. - media anual de absenteismo

(166)

- media anual de rotatividade: (i) por iniciativa da empresa
(ii) por iniciativa do pessoal

60. Qualificacao Profissional (fornecer %)

(167)

Em 1987:

Area	pos-graduacao	graduacao univers.	escola tecnica	segundo grau	primeiro grau
projeto					
engenharia					
manufat.					
administr.					

Em 1992:

(167)

Area	pos-graduacao	graduacao univers.	escola tecnica	segundo grau	primeiro grau
projeto					
engenharia					
manufat.					
administr.					

61. Numero de anos do pessoal na empresa

(166)

Anos / Area	pessoal nao direto de producao ¹⁸	pessoal direto de producao ¹⁹
0 - 2		
2 - 5		
+ 5		

62. Estrategia de Treinamento

(168)

(informar frequencia dos cursos, duracao media, tipos de cursos, pessoal com acesso aos cursos)

-treinamento formal: (i) na empresa; (ii) cursos externos

-treinamento informal: (i) no emprego; (ii) outros tipos

63. Quais sao as principais tipos de 'materias' lecionadas nesses cursos de treinamento (qualificar de 1 a 5 para cada categoria) (168)

Tipo de materia	alta gerencia	media gerencia	pessoal operativo ²⁰

¹⁷ por exemplo uso de grupos de trabalho na producao, estruturas organizacionais descentralizadas, ou algum tipo de programa participativo.

¹⁸ Incluir gerencia alta, media, pessoal de planejamento nas areas administrativas, manufatura, planejamento e projeto do produto.

¹⁹ Incluir pessoal operativo nas areas de projeto de produto e manufatura.

²⁰ Pessoal operativo nas area de projeto, engenharia e manufatura.

conhecimentos tecnicos			
conhecimento gerencial			
'cultura' da empresa			

64. Estrutura do Treinamento

(169)

- Tem pessoal na empresa onde a maior prioridade deles(as) e o treinamento de outros funcionarios ? (fornecer numero de pessoal)
- Fonte de qualificacoes existentes na empresa: (qualificar de 1 a 5)
 - contratacao (temporal ou permanente)
 - treinamento interno
 - treinamento externo
 - sub-contratacao
- Esforco da empresa (em \$ e numero de pessoal treinadas por ano) em treinamento
- quem identifica e planeja as necessidades de treinamento do pessoal em geral ?

65. Avaliacao do desempenho

(170)

Em que base o pessoal e avaliado para fixar salarios, promocoos etc. (qualificar de 1 a 5)

Criterio/categ.	alta gerencia	gerencia media	pessoal operativo
qualificacoes formais			
experiencia			
responsabilidade (lealdade a firma)			
situacao geral da empresa			
desempenho no servico			
outros (especificar)			

66. A estrutura de cargos e de carreira profissional tem mudado como resultado da introducao/utilizacao de novas formas organizacionais ?

(170)

67. Em que base o pessoal (alta gerencia, media gerencia e operativo) e avaliado para promocoos e salarios :

(170)

	alta gerencia	media gerencia	pessoal operacional
individual			
grupo			
secao/depart.			
outros (especificar)			

68. O atual sistema de avaliacao para fixar salarios e promocoos tem mudado (pelo menos em algumas areas) como resultado da introducao ou uso de novas formas organizacionais ?

(170)

69. Nivel salarial na firma em relacao ao mercado (nacional ou regional).

(170)

	alta gerencia	media gerencia	pessoal operacional
aacima da media			
na media			
abaixo da media			

70. Diferencas salariais (media) - pessoal de linha (usar escala de 1 a 20)

(171)

Area/categ.	nao-qualificado	qualificado	tecnicos	engenheiros
Projeto do produto				
Manufatura				

71. Outro(s) tipo de Recompensa

(173)

Alem dos salarios, informar sobre outro tipo de recompensa (tangivel e intangivel) que a empresa utiliza para motivar o pessoal. especificar que categorias do pessoal tem acesso a este tipo de recompensa.

72. Pessoal no Projeto do Produto: (fornecer %)

(175)

categoria / ano	1987	1992
engenheiros		
desenhista tecnicos		
desenhista assistente		
detalhista		

73. Numero do Pessoal na manufatura (fornecer %)

(176)

categoria / ano	1987	1992
engenheiros		
tecnicos		
producao direto qualificados		
producao direto nao-qualificados		

74. Condicoes de emprego (qualificar de 1 a 5)

(177)

item / categoria	alta gerencia	media gerencia	pessoal operacional
estabilidade laboral			
oportunidades de carreira profissional			
oportunidades de treinamento			

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ROTEIRO DE ENTREVISTAS: PROJETO DO PRODUTO

1. Informações Gerais

- 74a. Fornecer prioridade de I a 5 para os seguintes fatores: (145)
- principal fonte de competitividade da empresa:
 - preço
 - rapidez de resposta ao mercado ou disponibilidade de produtos
 - qualidade do produto
 - estratégia de manufatura :
 - planejamento da produção 'forte'
 - produção continua (não máquina parada)
 - organização logística efetiva
 - base de dados de engenharia confiável
 - ênfase no controle central da produção
 - rapidez na reorganização das operações de manufatura para atender mudanças de demanda
 - estratégia do desenvolvimento no projeto de produtos
 - projeto de produtos não é prioridade
 - desenvolvimento de projetos em forma modular
 - rapidez no desenvolvimento do projeto
 - rapidez na reorganização do desenvolvimento do projeto para atender mudanças de demanda
 - estratégia para uso de CAD
 - uso de CAD para apoio a manufatura (eg. projeto de ferramentas, layout e moldes)
 - CAD para projeto (construção) de novos produtos
 - CAD para análise de engenharia (FEA), simulação
 - CAD para gerar programa de controle numérico
 - CAD para desenvolver produtos de forma modular
 - CAD para rapidez de desenho (detalhe, cópias)
 - CAD para gerar listagem de materiais/partes
 - prioridade do projeto do produto com relação a manufatura
 - projeto (conceito, análise, projeto e documentação)
 - engenharia industrial
 - planejamento da produção
 - manufatura
 - em que medida as atividades realizadas na etapa do desenvolvimento do produto facilitam as seguintes áreas de manufatura:
 - engenharia industrial
 - planejamento da produção
 - manufatura

75. CAD: Configuração tecnológica (178)

- hardware básico
- software básico (sistema operacional, aplicações)
- Configuração do sistema (layout físico, layout lógico)
- desenvolvimento/customização do sistema (base de dados, software, hardware)

75a. Indicar de I a 5 , como e a atual configuração tecnológica em termos de(379)

- grau de dispersão geográfica das estações de trabalho
- grau de capacidade de processamento em cada estação de trabalho
- grau de integração entre as estações de trabalho

75b. Utilizando a escala mostrada, indicar o nível de intervenção para cada categoria profissional durante

- (i) o planejamento estratégico das atividades de projeto;
- (ii) implementação, desenvolvimento do sistema;
- iii) operação e administração do sistema. (378)

,nível de intervenção:

- 1- não intervenção .
- 2- infamados antes da mudança
- 3- consultados antes da mudança
- 4- alguma participação na decisão/operação/administração do sistema
- 5- ampla participação na decisão/operação/administração do sistema

	Estratégia	Implementação e desenvolvimento	Operação e administração
Gerente			
Chefe seção			
Projetista sênior			
Projetista			
Desenhadores			
Copista			
Suporte CAD			
Programadores CN e processista			
Outros: pessoal da Fabricação; Engenharia de Processo; consultores externos			

75b. Durante o processo de seleção/instalação dos equipamentos, alem dos fatores técnicos, foram levados em conta fatores humanos 2l 7 (478)

Quem realmente fez a seleção dos equipamentos
Quem fez a decisão final formal ?

2 l isto e, critérios para aumentar (favorecer) ou diminuir (limitar): (i) interverição do operador; (ii) informações de produção p/operador; (iii) controle sobre processo de produção

77. Variedade de produtos projetados (142)

ano	1987	1992
Variedade 22		
Variabilidade 23		
% partes prontas 24		
% partes compradas 25		
% partes encomend-1 26		
% partes encomen- 27		

78. Qual dos seguintes fatores empresa tem maior importância Para eficiente desempenho de atividades na área do projeto do produto? (qualificar de I a 5) (184)

-o prevalente 'ambiente' interno de relações Industriais

- a presente política de treinamento
- a existência de pessoal altamente qualificado no projeto
- a existência de tecnologia de ponta (CAD)
- a forma como a tecnologia é utilizada
- a estrutura organizacional utilizada na área de projetos
- a estrutura da tomada de decisão na área do projeto
- a forma como o pessoal é motivado e recompensado (ex. sistema de carreira profissional,
- outros (especificar)

79. A área do projeto do produto contribui Para a competitividade da empresa através de: (qualificar de I a 5) (184)

- possibilidade de oferecer um maior numero de soluções alternativas Para um novo produto
- rapidez atingida para terminar o projeto (concepção e execução)
- rapidez na geração (produção) do projeto (desenho detalhado, geração de listagem de partes)
- rapidez na modificação de projetos existentes
- uso CAD Para análise de engenharia (simulação, modelamento matemático, cálculo por elementos finitos) -uso de CAD Para ferramental, moldes, layout -uso de CAD para desenvolver os principais produtos da firma -CAD Para produção do programa de controle numérico

80. Capacidade Tecnológica e a da firma na área do projeto do produto (I 85)
(qualificar de I a 5)

- geração na firma de todo o projeto novo
- geração de grande parte de um novo projeto
- geração de pequena parte de projeto novo
- capacidade para gerar partes complexas
- capacidade para gerar parte simples
- capacidade para modificar existentes desenhos

-
- 22 numero de diferentes produtos manufaturados no ano referido
- 23 % de produtos totalmente novos
- 24 % de partes comuns a outros produtos existentes na empresa ou de modelos prévios
- 25 % de partes compradas de fornecedores e que foram desenvolvidas (projetadas e produzidas) totalmente pelo fornecedor
- 27 % de partes encomendadas, mas que foram totalmente projetadas (projeto geral a detalhado) na empresa e só tabacadas no fornecedor

-capacidade para competir internacionalmente em termos de desenho inovativo

80a.. Os esforços tecnológicos da empresa estão orientados Para: (383)
(qualificar de I a 5)

- aumentar a variedade de produtos a fabricar
- desenvolver novos produtos
- alongar a capacidade de utilização do equipamento existente
- utilizar plenamente a capacidade da planta
- outros (especificar)

80b. Esforços organizacionais da firma estão dirigidos Para: (1-5) (279)

- melhorar a utilização da mão-de-obra
- melhorar utilização dos equipamentos
- reduzir o tempo de resposta Para o mercado
- orientar o projeto Para facilitar a fabricação do produto
- minimizar o custo de produção dos projetos
- facilitar a interação entre as áreas de projeto e manufatura

80c. Intensidade do uso de tecnologia de ponta na área do projeto(185)

- número do pessoal usando CAD or CAE
- numero total do pessoal na área do projeto

80d. Fontes de conhecimento tecnológico na área de projeto (186)

- proprio grupo da empresa
- relações com clientes e/ou fornecedores
- contratação de consultoria extrema nacional
- contratação de consultoria extrema estrangeira
- outros (especificar)

80e. Indicar o nível de coordenação que existe na área do projeto do produto

- (i) dentro da unidade de trabalho
- ; (ii) entre as unidades de trabalho (380)

-Tipo de mecanismos para coordenação:

- 1- sistema burocrático (papel)
- 2- hierarquia formal
- 3-contato gerencial direto
- 4-estrutura organizacional: ex. estrutura matricial
- 5-uso de grupos de trabalho inter-departamentais, comitês multi-departamentais

-Tempo e esforço que o responsável pela área gasta em atividades de coordenação

- 1 -mínimo esforço de coordenação requerido.
- 2-limitada quantidade de coordenação Requerida (encontros ocasionais)
- 3-moderada qualidade de coordenação requerida
- 4-considerável quantidade de coordenação requerida
- 5-máxima qualidade de coordenação requerida

	Dentro da unidade de trabalho	Entre unidades de trabalho
Tipo de coordenação		
Tempo e esforço		

80f. Aos usuários do equipamento CAD (dentro da unidade de trabalho ou grupo) Ih
esta permitido(I - 5) (382)

	projetista	desenhista	Operadores (ex. copistas)	Pessoal outras Áreas (ex. manufatura, processos)
Organizar seu Próprio Serviço 28				
Organizar Planejamento De tarefas Detalhado 29				
Coordenar Funções 30				
Eleger chefe do Grupo				
Executar funções de Supervisão 31				

II. Dentro da unidade de Trabalho

- 81a. (i) Organograma da área do projeto. (179)
(ii)Forma de estruturar (distribuir) o serviço
(iii) Quais os objetivos principais para a utilização de algumas novas formas
organizacionais na área do desenvolvimento (projeto) do produto ?

81b. Indicar em que medida as ordens de produção dirigidas para alguma seção
específica são: (escolher uma) (480)
-descrição detalhada sobre como realizar as atividades de trabalho (em que estação
de trabalho, técnicas a utilizar)
-descrição moderada sobre como realizar o trabalho
-descrição geral sobre como realizar o trabalho
-objetivos gerais (especificações técnicas, materiais, data de entrega), sendo que o
responsável pela área organiza detalhadamente as atividades do projeto
-objetivos gerais (especificações técnicas, materiais, datas de entrega) sendo
que a organização detalhada e feita pelos membros do grupo de trabalho.

81c. Qual a frequência de emissão das ordens de produção a nível de unidade de trabalho.

81d. Nível de especialização dentro da unidade de trabalho: (480b)
-baixa: pessoal pode realizar alto numero de tarefas diferentes dentro da sua
categoria profissional
-alta: pessoal pode realizar um baixo numero de operações diferentes dentro da
sua categoria profissional.

-
- 28 (i) junto com colegas do grupo, distribuir o serviço; (ii) definir junto com colegas forma de realizar o
serviço.
29 (i) determinar ordem de prioridade detalhada; (ii) ter algum tipo de controle sobre quando fazer que
tarefa especifica
30 ex. relações com outras escoes; tarefas preparatórias; procure de preparatórias etc.
31 atividades de supervises com, desempenho no serviço, qualidade do serviço

81e.-Dentro da unidade de trabalho (grupo), são possíveis 'buffers' entre as estações de trabalho individuais ?

81f.-Se existem 'buffers' entre as estações de trabalho duram eles?

81g.E possível mudar a ordem da sequência de operações entre as estações de trabalho individual ?

81h.Um erro numa estação. individual de trabalho permanece dentro da unidade de trabalho ou se espalha a outras unidades de trabalho ?

II. Entre das unidades de Trabalho

82a. (i) Organograma da área do projeto. (179)
(ii) Forma de estruturar (distribuir) o serviço

82b. Indicar em que medida as ordens de produção dirigidas para alguma o departamento de desenvolvimento do produto especifica são: (escolher uma) (480)
-descrição detalhada sobre como realizar as atividades de trabalho (em que estação de trabalho, técnicas a utilizar)

-descrição moderada sobre como realizar o trabalho

-descrição geral sobre como realizar o trabalho

-objetivos gerais (especificações técnicas, materiais, data de entrega), sendo que o responsável pela área organiza detalhadamente as atividades do projeto

-objetivos gerais (especificações técnicas, materiais, datadas de entrega) sendo que a organização detalhada e feita pelos membros do grupo de trabalho.

82c. Qual a frequência de emissão das ordens de produção a nível de departamento de projeto do produto.

82d. Nível de especialização dentro do departamento de projeto: (480b)

-baixa: pessoal pode realizar alto numero de tarefas diferentes dentro da sua categoria profissional

-alta: pessoal pode realizar um baixo numero de operações diferentes dentro da sua categoria profissional.

82e. -Entre unidades de trabalho (ex. grupos diferentes), são possíveis esperas ? existem 'buffers' entre as unidades de trabalho ?

82f. -Se existem 'buffers' entre as unidades de trabalho, quanto tempo duram eles?

82g. -É possível mudar a ordem da sequência de operações entre as unidades de trabalho ?

82h. -um erro numa unidade de trabalho permanece dentro da unidade de trabalho ou se espalha a outras unidades de trabalho ?

IV Interface Projeto/Manufatura

83a.Explicar em que grau (como) a área de projeto (desenho) do produto esta ligada a área de fabricação.

83b. Para a aprovação final do projeto de novo produto (ou parte), e necessária a participação de algum representante da (i) fabricação (ii) da engenharia de processos?

83c. Se a resposta da pergunta anterior é positiva, em que estágio do projeto do produto o projeto é revisado ?

- conceito (idea)
- desenho preliminar
- prototipo
- projeto pronto

83d. O pessoal do projeto trabalha (consulta) com pessoal da fabricação em algum estágio do desenvolvimento do projeto ?

83e. Existe alguma estrutura organizacional nova feita para coordenar melhor a interface projeto/manufatura ?

83f. Pessoal da manufatura pode fazer mudanças no projeto do produto ?

83g. O novo produto e o ferramental utilizado para fabricação e desenvolvido simultaneamente ?

83h. Pessoal da área de projetos uma de posto com pessoal da fabricação ?

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ROTEIRO DE ENTREVISTAS: MANUFATURA

1. Informações Gerais

- 83.** Tipo de operações de manufatura (%) (188)
- transformação molecular
 - montagem
 - usinagem

84. Tamanho médio dos lotes de fabricação

Tamanho do lote	% do total fabricado
1 - 10	
11 - 100	
101 - 500	
501 - 2000	
+2000	

84a Fonecer prioridade de I a 5 para os seguintes fatores (145)

- principal fonte de competitividade da empresa:
 - preço
 - rapidez de resposta ao mercado ou disponibilidade de produtos
 - qualidade do produto
- estratégia de manufatura:
 - planejamento da produção 'forte'
 - produção continua (não maquina parada)
 - organização logística efetiva base de dados de engenharia confiável
 - ênfase no controle central da produção
 - rapidez na reorganização de operações de manufatura para atender mudanças de demanda
- estratégia do desenvolvimento no projeto de produtos
 - projeto de produtos não e prioridade
 - desenvolvimento de projetos em forma modular
 - rapidez no desenvolvimento do projeto
 - rapidez na reorganização do desenvolvimento do projeto para atender mudanças de demanda
- estratégia para uso de CAD
 - uso de CAD para apoio a manufatura (eg. projeto de ferramentas, layout e moldes)
 - CAD para projeto (construção) de novos produtos
 - CAD para análise de engenharia (FEA), simulação
 - CAD para gerar programa de controle numérico
 - CAD para desenvolver produtos de forma modular

-CAD para gerar listagem de materiais/partes

- prioridade do projeto do produto com relação a manufatura
 - projeto (conceito, análise, projeto e documentação)
 - engenharia industrial
 - planejamento da produção
 - manufatura

-Em que medida as atividades realizadas na etapa do desenvolvimento do Produto facilitam as seguintes áreas de manufatura:

- engenharia industrial
- planejamento da produção
- manufatura
- outros

84b. Quem determinou as prioridades acima mostradas (145a)

85. Organização da produção (191)

Em cada item responder:

(a) intensidade de uso (% do número total de seções/áreas/departamentos aplicando a técnica referida);

(b) Em que medida essas técnicas trazem os benefícios esperados.

(c) Por que essa área foi escolhida para a implementação

(i) organização das operações de produção: (% do total da planta)

- .por produto
- .por processo
- .outros (células, grupos)(ver seguinte pergunta)

(ii) Indicar de I a 5, como é a atual configuração da tecnologia em termos de

- grau de dispersão geográfica
- grau de 'autonomia' de cada estação de trabalho/área 32
- grau de integração ou coordenação entre estações de trabalho

(iii) uso de novas formas organizacionais: (só responder sim ou não)

- . células de manufatura; redução tempo de preparo de máquina; linhas de montagem e/ou usinagem em forma de U; uso de cartões 'kanban'; uso de mecanismos de controle na linha de produção (ex. luzes); tecnologia de grupo;

.uso de princípios de Qualidade Total da Produção, círculos de qualidade;

.JIT externo: único fornecedor certificação de fornecedores; entrega na linha de montagem/usinagem; fornecedores por família de peças;

(iv) Produção em grupos: rotação de postos de trabalho dentro dos grupos; rotação de postos de trabalho entre grupos diferentes; responsabilidade individual pela qualidade do produto; responsabilidade do grupo pela qualidade do produto; sistema de pagamento baseado no desempenho individual; sistema de pagamento baseado no desempenho do grupo.

(v) Células de manufatura: produção em grupos + tecnologia de grupo + layout em célula;

321º é, capacidade para o operador realizar as ações necessárias para continuar a produção.

(vi) trabalho 'alongado': operadores multifuncionais (operadores realizam alem da operação da maquina tarefas auxiliares, responsáveis pelo controle da qualidade do seu trabalho e realizam em alguns casos trabalhos rotineiros de manutenção da maquina)

(vii) técnicas avançadas: célula de manufatura + trabalho alongado + pessoal do chão da fabrica faz o cronograma detalhado de trabalho dentro da célula; organizam entre eles a forma de distribuir o serviço; realizam quando necessário modificações no programa do controle numérico; podem realizar outras tarefas fora da célula (ex. coordenação com outras seções).

(viii) uso de outras técnicas avançadas: controle estatístico do processo; geração do programa de controle numérico; modificação do programa controle numérico;

86. Qual foi objetivo(s) para utilizar algumas novas formas organizacionais na produção ?
(190)

87. Quais os ganhos obtidos a nível de chão de fabrica como resultado da aplicação dos acima mencionadas novas formas organizacionais?(fornecer indicadores concretos: tempos médios de fabricação, tempos médios de preparo de maquina etc.)
(191)

87a. Utilizando a escala mostrada, indicar o nível de intervenção para cada categoria profissional durante (i) o planejamento estratégico das atividades de @; (ii) implementação, desenvolvimento do sistema; (iii) operação e administração do sistema.
(678)

nível de intervenção:

- 1-não intervenção
- 2-informados antes da mudança
- 3-consultados antes da mudança
- 4-alguma participação na decisão/operação/administração do sistema
- 5-ampla participação na decisão/operação/administração do sistema

	estratégia	Implementação	Operação e administração
Gerente área			
Chefe seção			
Supervisor de linha			
Pessoal direto fabricação			
Engenharia Industrial (eng. Processos; eng. Planejamento)			
Outras Áreas: projeto do Produto			
Alta gerencia			
Consultores externos			

87b. Durante o processo de seleção dos equipamentos/ implementação do layout, além dos fatores técnicos, foram levados em consideração 'fatores humanos' 33) (678)

87c. (i) Quem realmente fez a seleção dos equipamentos da manufatura (678a)

(ii) Quem realmente fez a decisão sobre a atual configuração da tecnologia

(iii) Quem fez a decisão final

87d. Economias de escopo

(642)

Ano	1987	1992
Variedade 34		
Variabilidade 35		
% partes prontas 36		
% partes compradas 37		
% partes encomendadas 1 38		
% partes encomendadas -2 39		

87e. Qual dos seguintes fatores internos a empresa tem maior importância para o eficiente desempenho de atividades na fabricação? (qualificar de I a 5) (184)

-o prevalente 'ambiente' interno de relações industriais

- a presente política de treinamento

-a existência de pessoal altamente qualificado na fabricação

-a existência de tecnologia de ponta

-a forma como a tecnologia é utilizada

-a estrutura da tomada de decisão na área do projeto

-a forma como o pessoal é motivado e recompensado (ex. sistema de carreira profissional, o sistema salarial), as condições de emprego oferecidas)

-outros (especificar)

87f. A fabricação contribui para a competitividade da empresa através de: (qualificar de I a 5) (684)

-obtenção de baixos custos de fabricação

-rapidez atingida para terminar o produto

(execução)

-rapidez de adaptação a mudanças nas ordens de produção -qualidade na fabricação

-rápida reorganização p/resolver problemas inesperados

87g. Os esforços tecnológicos da empresa estão orientados para: (683)
(qualificar de I a 5)

-aumentar a variedade de produtos a fabricar

-desenvolver novos produtos

33 Isto é, critérios para aumentar ou diminuir (i) intervenção do operador; (ii) informações para operador da máquina; (iii) iniciativa do operador para tomar ações p/solução de problemas; (iv) controle da operação da máquina;

34 número de diferentes produtos manufaturados no ano referido

35 % de produtos totalmente novos

36 % de partes comuns a outros produtos existentes na empresa ou de modelos prévios

37 % de partes compradas de fornecedores a que foram desenvolvidas (projetadas e produzidas) totalmente pelo fornecedor

38 % de partes encomendadas a fornecedores, mas onde o projeto geral foi desenvolvido pela firma e o projeto detalhado foi desenvolvido pelo fornecedor

39 % de partes encomendadas, mas que foram totalmente projetadas (projeto geral e detalhado) na empresa e só tabacadas no fornecedor

- alongar a capacidade de utilização do equipamento existente
- utilizar plenamente a capacidade da planta
- outros (especificar)

87h. Esforços orizacionais da firma estão dirigidos para:(1-5)

- melhorar a utilização da mão-de-obra
- melhorar utilização dos equipamentos
- reduzir o tempo de resposta para o mercado
- orientar o projeto para facilitar a fabricação do produto
- minimizar o custo de produção dos projetos
- facilitar a interação entre as áreas de projeto e manufatura

88. Intensidade de uso de tecnologia de ponta: (196)

Pessoal:

- número total de pessoal direto de produção usando qualquer tipo de maquina
- número de pessoal direto de produção usando tecnologia de ponta

Equipamento:

- número total de equipamentos de produção na manufatura
- número total de equipamentos de ponta na manufatura

89. Fontes de conhecimento tecnológico na manufatura. (197)

(indicar de I a 5)

- próprio grupo da empresa
- informações de clientes ou fonecedores
- consultoria extrema
- arrancos especiais com outras instituições/empresas
- P&D interno da *fmna*
- outros (especificar)

90. A **firma** tem atingido alguma norma internacional de qualidade ? (198) (ex. norma ISO9000). Fonecer % de produtos principais que tem atingido essa norma de qualidade.

91. Indicadores de produtividade (198)

Ano	1987	1992
Numero total pessoal no Projeto do produto		
Numero total pessoal de manufatura		
Valor total equipamentos de produção (\$)		
Valor total (\$) dos Produtos manufaturados		

92. Fontes de competitividade na manufatura (200)

(qualificara de I a 5)

- ênfase no planejamento e controle da produção
- baixo custo de produção
- rapidez para mudar de tipo de produto para outro
- mínimo tempo de produção
- qualificações/experiência do pessoal
- tecnologia utilizada
- utilização de novas formas organizacionais no chão-de-fábrica
- alta produtividade do pessoal direto da manufatura
- alta produtividade do equipamento utilizado
- qualidade das operações de 'suporte' (controle de inventários, engenharia industrial) a produção
- eficiência dos supervisores de linha para controlar a produção

-outros (especificar)

93. Capacidade tecnologica atingida pela firma na manufatura (201)
(qualificar de I a5)

- licença estrangeira para produzir para o mercado interno
- capacidade para realizar maiores melhoras em processes industriais previamente estabelecidos
- capacidade para realizar ligeiras melhoras em processes industriais previamente estabelecidos
- capacidade para produzir de forma independentes uma ampla variedade de produtos
- capacidade para concorrer internacionalmente (preço e qualidade)

94. Onde é feito o programa de controle numérico ?

95. Quem faz e onde e feito o planejamento geral da produção ?

96a. Indicar o nível de coordenação que existe na fabricação (i) dentro da unidade de trabalho; (ii) entre as unidades de trabalho (380)

- Tipo de mecanismos para coordenação:
- 1- sistema burocrático (papel)
 - 2- hierarquia formal
 - 3- moderada quantidade de coordenação adquirida
 - 4- quantidade de coordenação adquirida
 - 5- máxima qualidade de coordenação requerida

Tempo e esforço que o responsável pela área gasta em atividade de coordenação

- 1- mínimo esforço de coordenação requerido
- 2- limitada quantidade de coordeno requerida (escontros ocasionais)
- 3-moderada qualidade de coordenação requerida
- 4-considerável quantidade de coordenação adquirida
- 5-máxima quantidade de coordenação requerida

	Dentro da unidade de trabalho	Entre unidade de trabalho
Tipo de coordenação		
Tempo e esforço		

96b. Ao pessoal direto da produção (dentro da unidade de trabalho ou grupo) lhes esta permitido: (1-5) (682)

	Chefe seção	Supervisor de linha	Operador de máquina	Pessoal outras Áreas (ex. eng. Industrial, Processos)
Organizar seu Próprio serviço 40				
Organizar planejamento de tarefas detalhado 41				
Coordenar Funções 42				
Eleger chefe do Grupo				
Executar Funções de Supervisão 43				

II. Dentro da Unidade de Trabalho

97. (i) Organograma da área/seção. (679)
(ii) Forma de estruturar (distribuir) o serviço
(iii) Quais os objetivos principais para a utilização de algumas novas formas organizacionais na área escolhida ?

98. Indicar em que medida as ordens de produção dirigidas para alguma seção específica são: (encolher uma) (680)
-descrição detalhada sobre como realizar as atividades de trabalho (em que estação de trabalho, técnicas a utilizar) -descrição moderada sobre como realizar o trabalho -descrição geral sobre como realizar o trabalho -objetivos gerais (especificações técnicas, materiais, data de entrega), sendo que o responsável pela área organiza detalhadamente as atividades do projeto
-objetivos gerais (especificações técnicas, materiais, datas de entrega) sendo que a organização detalhada é feita pelos membros do grupo de trabalho.

99. Qual a frequência de emissão das ordens de produção a nível de unidade de trabalho.

100. Nível de especialização dentro da unidade de trabalho: (680b)
-baixa: pessoal pode realizar alto numero de tarefas diferentes dentro da sua categoria profissional
-alta: pessoal pode realizar um baixo numero de operações diferentes dentro da sua categoria profissional.

40 (i) junto com colegas do grupo, distribuir o serviço; (ii) definir junto com colegas forma de realizar o serviço.
41 (i) determinar ordem de prioridade detalhada; (ii) ter algum tipo de controle sobre quando fazer que tarefa especifica
42 ex. relações com outras seções; tarefas preparatórias; procure de informações etc.
43 atividades de supervises como, desempenho no serviço, qualidade do serviço

116. O responsável pela área (nível chão de fábrica) lhe foi delegada responsabilidade realizar decisões no pronto de operação ?

117. Ao responsável pela área (nível chão de fábrica) lhe e permitido analisar seu método de trabalho para melhora-lo?

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